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SEASONAL DISTRIBUTIONS OF PLANKTON IN THE STRAIT OF JUAN DE FUCA

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Plankton investigations in the Strait of Juan de Fuca were conducted during seven cruises in 1976. Phytoplankton, zooplankton, and ichthyoplankton communities were sampled to study their composition and distributional characteristics. The phytoplankton was numerically dominated by small microflagellate species during the late winter and early spring. By the middle of May large diatoms had become more important. During late June a diatom bloom composed primarily of Skeletonema costatum was in progress and chlorophyll concentrations as great as 25 mg/m^3 were measured. Microflagellates were abundant again later in the year. The biomass of the zooplankton increased steadily through the late winter and spring. The highest levels seen to date coincided with the June phytoplankton bloom. The most numerous zooplankters were copepods, especially near-surface and surface living calanoids and cyclopoids. The ichthyoplankton, composed principally of fish larvae, commonly included members of the Osmeridae, Gadidae, and Cottidae. Hexagrammidae larvae were notable because they were almost exclusively pleustonic.

1. INTRODUCTION

The main objective of the plankton studies conducted in the Strait of Juan de Fuca during 1976 was to describe the seasonal distribution and composition of phytoplankton and zooplankton populations. The information collected will be included in an overall biological baseline which will aid in monitoring the effects of petroleum discharges in the Strait of Juan de Fuca.

This report summarizes information obtained in 1976. Available data are presented concerning phytoplankton species composition, phytoplankton biomass as indexed by chlorophyll concentration, zooplankton densities in the water column and at the surface, and distribution of ichthyoplankton. Some preliminary interpretations of the results are included.

2. SAMPLING AND LABORATORY METHODS

Seven sampling cruises to the Strait of Juan de Fuca were conducted at intervals of approximately 6 weeks during 1976. Sampling activities are summarized in table 1. In general, during each cruise a transect of three stations each was made across the Strait at Port Angeles, Pillar Point, and Neah Bay near Cape Flattery (fig. 1). Only the Port Angeles line was occupied during cruise SF7603 due to mechanical failure of the vessel.

At every station occupied, an obliquely towed plankton net and a pleuston sampler were used to sample the zooplankton. A double bongo net was used for the initial three cruises for oblique tows, but was replaced by a single net of similar configuration (333-μm mesh, 60-cm mouth diameter) suspended in a newly designed frame. The oblique net was towed from 50 m to the surface while being slowly retrieved. For cruise SF7607 a digital flowmeter (General Oceanics, model 2030) was fitted to the net frame to more accurately measure the volume of water filtered. The pleuston net, equipped with a 333-μm mesh net, was towed at the surface, away from the ship's wake, for 10 minutes. The zooplankton samples were preserved with sodium acetate buffered formalin and returned to Seattle for analysis.

At each midchannel station (2, 5, 8) a bottle cast and a series of vertical closing-net hauls were made in addition to the oblique and pleuston tows. Niskin bottles (1½-ℓ) were used to obtain water samples at 0, 10, 20, 30, 40, and 50 m. Subsamples were drawn to determine chlorophyll and pheopigment content and the phytoplankton species assemblage. Phytoplankton and microzooplankton subsamples were preserved in 1.5% buffered formalin. These were later analyzed in the laboratory using the inverted microscope technique described by Utermöhl (1931). Pigment concentration was measured with a shipboard fluorometer (Turner®, model 111) following the discrete sample method of Lorenzen (1966). The vertical hauls were made using a 211-μm-mesh, 60-cm-mouth-diameter net. Usual depth strata sampled were: near bottom to 100 m, 100 m to 50 m, 50 m to 25 m, and 25 m to 0 m. Sampling intervals were adjusted for shallower stations.

Settled volumes of all zooplankton samples were determined. Large or otherwise conspicuous organisms were removed, counted, and identified at least to major taxonomic group. Fish eggs and larvae were delivered to the Northwest Fisheries Center of the National Marine Fisheries Service for further identification. Subsamples were obtained with a Folsom plankton splitter (McEwen et al., 1954) and sorted entirely to major taxonomic groups. Principal species and copepods were identified and counted.

During cruises SF7602 and SF7604-SF7607 a hand-lowered CSTD (Interocean, model 513A) was employed at the midchannel stations to collect salinity and temperature information in the upper 100 m. It is anticipated that a new CTD system will be used on future cruises.

Table 1. Summary of sampling activities in the Strait of Juan de Fuca during 1976.

Cruise	Date	Vessel	No. of Stations	No. of Samples: Oblique	Pleuston	Vertical	Phytoplankton	Microzooplankton	Chlorophyll	Pheopigments	CSTD Casts
SF7601	23-24 Feb	Commando	8	8	8	11	18	2	18	18	0
SF7602	5-6 Apr	Commando	9	9	9	11	18	5	18	18	3
SF7603	17-18 May	Hydah	7	7	7	7	18	4	18	18	0
SF7604	28-30 June	Snow Goose	9	9	9	11	18	3	18	18	3
SF7605	3-5 Aug	Snow Goose	9	9	9	11	18	4	18	18	3
SF7606	14-16 Sept	Snow Goose	9	9	9	11	18	3	23	23	3
SF7607	12-15 Nov	Snow Goose	9	9	9	11	18	3	18	18	3
		Totals:	60	60	60	73	126	24	131	131	15

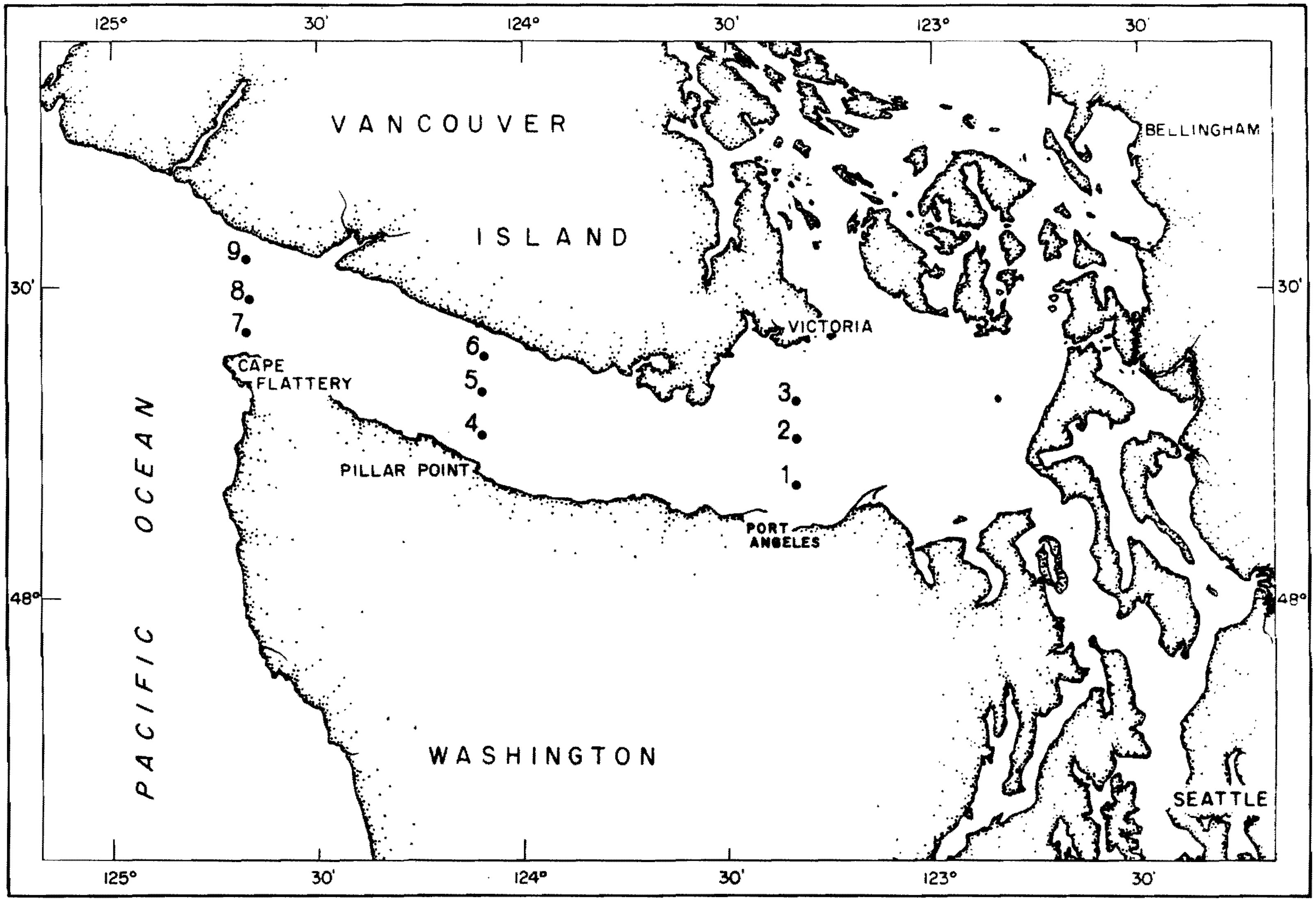

Figure 1. Area chart and station locations for Strait of Juan de Fuca cruises.

3. PHYSICAL CHARACTERISTICS

The Strait of Juan de Fuca is a deep estuary connecting the inland marine waters of Washington with the Pacific Ocean (fig. 1). It is characterized hydrographically as a two-layered system with an annual net westward flow of relatively fresh water in the upper 30 m and more saline oceanic water below. The Strait receives a large influx of fresh water from drainages into Puget Sound and the Fraser River which empties into the Strait of Georgia to the north. There are two periods of high runoff. The major one occurs in late spring when snow melt is at a maximum in the Cascade and Olympic mountain ranges. A smaller runoff period occurs during late fall and winter when precipitation is high.

Herlinveaux and Tully (1961) have treated aspects of the physical oceanography of the Strait of Juan de Fuca. They found that salinity dominated the density structure throughout the year. During the summer a thermocline coincided with the halocline to reinforce the stability of the upper layer. In the winter, waters were either isothermal or the upper layers tended to be slightly colder than deeper layers. The authors considered the tides and tidal currents as important oceanographic components of the Strait of Juan de Fuca system. During flood tide dense ocean water enters the outer Strait and flows beneath the upper zone. The inner Strait is a region of exchange where brackish water contributed by the Strait of Georgia is mixed to homogeneity and enriched with ocean water. Part of this water returns to the deep zone of Georgia Strait, and part escapes seaward in the upper zone of the Strait of Juan de Fuca during ebb tide.

We have made CSTD casts during five cruises. The vertical profiles of temperature, salinity, and density are given in Appendix A. The pattern is generally consistent with that described by Herlinveaux and Tully (1961). During April (SF7602) the deeper waters tended to be slightly warmer than overlying layers. For all cruises the surface salinity increased in a seaward direction. A well-developed surface layer in late June (SF7604) coincided with a peak of phytoplankton biomass and is probably an important factor influencing the development of the bloom. That salinity controls density is apparent from profiles obtained during later cruises. Although surface waters were warmed, the lack of a well-defined halocline prevented the formation of a shallow stable layer.

4. CHLOROPHYLL DISTRIBUTION

Knowledge of the details on the seasonal variation of phytoplankton biomass in the area is sparse. Phifer (1933) found four diatom maxima in the waters of the San Juan Islands; the two major ones occurred from late May to early June and mid-July to mid-August. Winter et al. (1976) noted that the annual cycle of phytoplankton growth was dominated by several intense blooms between early May and September in Puget Sound and commented that the onset of blooms in the main basin of Puget Sound was late for the latitude of 48°N. They stated that algal concentrations were changing drastically within time periods shorter than the biweekly sampling interval during 1963-65. They shifted to daily sampling for later studies. Munson (1969) found incident light, freshwater runoff, and tidal ranges to be the three factors most useful in forecasting onset and disappearance of blooms in Puget Sound. These factors may also be important in the Strait of Juan de Fuca where tidal currents and thermohaline properties affect water column stability.

Vertical profiles and integrated values for chlorophyll and pheopigments in the upper 50 m are given in Appendix B. Chlorophyll concentrations were generally less than 2 mg/m^3 during the first three cruises except during early April when values as high as 5 mg/m^3 were observed at station 8. A large phytoplankton bloom was in progress at all stations during late June. Chlorophyll concentrations ranged up to 25 mg/m^3 at station 8. By early August chlorophyll content was again less than 2 mg/m^3 This condition was encountered again during the next two cruises with the exception that over 3 mg/m^3 was found at station 8 during November. During all seven cruises taken, the highest surface chlorophyll concentration occurred at station 8. Perhaps this is related to circulation patterns or productivity characteristics in adjacent coastal water.

Statistical variability was briefly examined during cruise SF7606. Six bottle casts were made in succession to sample surface sea water at station 5. Chlorophyll content was measured for each cast. A 95% confidence level of ±.07 about the mean of 0.81 mg/m^3 was calculated. This measure of variability includes errors in analysis as well as patchiness in the immediate vicinity.

5. PHYTOPLANKTON SPECIES ANALYSIS

Information in the literature concerning phytoplankton species distribution in the area has been limited mainly to the San Juan Archipelago (e.g., Gran and Thompson, 1930; Phifer, 1933; Phifer, 1934a, Thompson and Phifer, 1936) and Puget Sound proper (Hirota, 1967; Booth, 1969). Phifer (1934b) reported the vertical distribution of diatoms in the Strait of Juan de Fuca for one cruise during July. He found that most diatoms were concentrated in the upper 25 m and placed the maximum concentration at 10 m.

The present study is being conducted to more completely characterize the spatial and temporal distributions of the phytoplankton species in the Strait of Juan de Fuca. To date surface and 50-m samples have been enumerated for six cruises. The tabulated data are presented in Appendix C.

Phytoplankton count data are in part analyzed as comparisons of the species composition of the samples. The Percentage Similarity (PS) index (Whittaker, 1960) has proved to be the most useful approach to help determine how alike samples are with respect to species composition. The PS of two samples, X and Y, is calculated as follows:

$$PS = 100 - 50 \left(\sum_{i=1}^{n} |x_i - y_i| \right) = \sum_{i=1}^{n} \min \left(x_i, y_i\right) ,$$

where x_i and y_i are the percents of total individuals that belong to the i^{th} taxonomic category in samples X and Y, and n is the total number of categories. Miller (1970) used Monte Carlo computer techniques to show that PS is a downward-biased estimator. This bias decreases with increasing sample size and decreases with decreasing diversity of the population. That is, samples from a population strongly dominated by one or a few categories will tend toward a higher PS. PS is primarily sensitive to shifts in the more abundant groups. Miller (1970) found that with sample sizes of 2000 and 1000 individuals, a PS as low as 80% and 75%, respectively, could be obtained when comparing two samples taken from the same population. Because many of our samples contained less than 1000 individuals and because not all phytoplankton classifications were of equal taxonomic weight, the acceptance level required to consider two samples identical should be lowered somewhat. The following criteria were adopted:

> if PS $\geq$ 70, the samples showed excellent agreement and were considered to have the same population distribution;
>
> if 60 $\leq$ PS < 70, agreement was fair and it was likely that populations were the same;
>
> if PS < 60, agreement was poor and samples probably contained a different phytoplankton community.

The complete PS matrix computed for all surface samples counted from SF7601 to SF7606 is shown in table 2. The PS matrix obtained by averaging blocks of indices from each cruise is shown in table 3. From the averaged data it is apparent that cruises SF7601, SF7602, and SF7605 show excellent internal consistency. That is, for any one cruise, the species distribution could be considered identical for all three stations. Cruises SF7604 and SF7606 show somewhat lower internal PS values. A closer look at station-by-station comparisons revealed that, for both cruises, stations 5 and 8 showed excellent agreement, but station 2 had a different phytoplankton community. The raw data showed that in both cases there were relatively fewer microflagellate species and more large diatoms for the inner station. No internal consistency check was possible for SF7603 because only station 2 was occupied.

The averaged PS matrix can be used in conjunction with the tabulated data to help elucidate the time course of phytoplankton species changes in the Strait of Juan de Fuca. During late February and early April (SF7601, SF7602) composition of the phytoplankton community remained constant (PS = 86.3). The dominant forms were microflagellate species. The important bloom organism, *Skeletonema costatum*, was first observed in early April at station 8. During May (SF7603) the phytoplankton community shifted toward larger diatom genera such as *Thalassiosira*. The PS index relating SF7602 with SF7604 was 16, which indicates that by June (SF7604) the phytoplankton community had altered significantly. A bloom characterized by large diatom cells was in progress during this cruise. Over 10^6 *Skeletonema costatum* cells/liter were observed at stations 2 and 8. Species of *Thalassiosira* and *Chaetoceros* were also abundant. The density

Table 2. Percent similarity index calculated by station for the surface phytoplankton community.

Cruise		SF7601		SF7602			SF7603	SF7604			SF7605			SF7606		
	Station	5	8	2	5	8	2	2	5	8	2	5	8	2	5	8
SF7601	2	95.2	67.4	95.3	96.5	87.5	57.0	3.0	22.6	21.0	95.2	94.9	94.7	41.8	82.6	88.4
SF7601	5		71.3	95.9	96.6	89.9	52.5	2.9	23.5	20.7	93.9	94.1	94.3	39.1	82.6	88.4
SF7601	8			68.4	69.3	77.6	53.4	2.9	24.6	21.4	66.6	67.0	67.4	39.9	68.1	67.2
SF7602	2				97.5	88.5	52.8	2.9	23.4	21.0	96.3	97.4	98.1	39.1	83.0	88.5
SF7602	5					89.5	54.4	3.0	23.9	21.2	96.4	96.0	95.9	40.5	83.2	88.9
SF7602	8						55.4	3.3	25.6	22.0	87.1	87.5	87.7	41.8	85.6	89.2
SF7603	2							19.8	41.1	38.9	55.0	53.9	53.3	54.1	59.5	60.4
SF7604	2								44.0	54.5	3.0	3.1	2.9	13.3	5.4	4.3
SF7604	5									78.5	22.9	23.4	23.1	44.0	27.3	25.0
SF7604	8										21.8	21.4	21.4	29.5	23.1	22.7
SF7605	2											97.6	97.2	40.8	83.2	89.8
SF7605	5												98.3	40.0	83.3	89.7
SF7605	8													39.6	83.4	89.3
SF7606	2														50.1	47.1
SF7606	5															91.3
SF7606	8															

of phytoplankton cells was much lower by early August (SF7605) and the population was again dominated by microflagellates. The species composition resembled closely that observed during SF7601 and SF7602. PS relative to SF7602 was 93.6. This high PS index is due to the large proportion of microflagellates in the populations. The actual microflagellate species may have varied, but preservation techniques and ordinary light microscopy make positive identification impossible. Therefore, the microflagellate category is a heterogenous group of species. During the middle of September (SF7606) species composition resembled that found in early August (PS = 71.0). Microflagellates continued to dominate the Strait of Juan de Fuca phytoplankton community except at station 2 where larger diatoms such as Chaetoceros spp. were relatively important.

Note on statistical reliability:

Hobson (1964) studied the error inherent in enumeration of phytoplankton samples. Three possible error sources were listed:

1. Distribution in the field (e.g., patchiness),

2. Subsampling from the water bottle,

3. Errors associated with counting technique.

He concluded that for less numerous cells (species) errors 1 and 3 are about the same. Error 2 was found to be small. For microflagellates error 2 becomes the largest component of variability. There seems to be no explanation other than that swarming may occur in the water bottle.

Table 3. Percent similarity matrix for phytoplankton averaged over cruise for SF7601-SF7606.

Cruise	1	2	3	4	5	6
1	78	86	54	16	85	66
2		92	54	16	94	71
3				33	54	58
4				59	16	22
5					98	71
6						63

Lund, Kipling, and LaCren (1958) looked at errors in the counting procedure. Their results for 95% confidence levels about a count are shown in figure 2. In this study we tried to attain counts of at least 100 individuals each for the three or four most abundant species. This results in a counting accuracy of ± 20%.

6. ICHTHYOPLANKTON

Ichthyoplankton is perhaps the most sensitive component of the plankton to oil pollution effects because larval forms may tend to aggregate in surface waters and because reproductive intervals are long. Analyses of fish egg and larvae samples are complete through the third cruise. These results are tabulated in Appendix D for the oblique and surface tows.

Osmerids (smelt) were the most abundant larval fish found in the upper 50 m during February (SF7601). They were most numerous off Neah Bay, reaching densities of almost two per cubic meter at station 9. On the average, however, larval densities were greater during April when several fish taxa occurred in significant numbers. Members of the Cottidae, Gadidae, and Osmeridae were prominent. Data from the Port Angeles transect during May cannot be used to characterize the entire Strait, but the sculpin *Artedius* sp. as well as other members of the Cottidae and Gadidae were present.

Samples taken with pleuston gear generally mirror those from the oblique tows with one notable exception. During both February and April *Hexagrammos* spp. (greenlings) were a most important pleustonic component. They were only rarely, however, caught by the oblique net. According to Hart (1973), adults of the family Hexigrammidae are common bottom fishes in shallow waters. Mostly copepods, but also amphipods, oikopleurans, and smaller fishes comprised the diet of young fishes taken in Strait of Georgia surface waters during late spring. The genus *Hexagrammos* provides an example of demersal organisms whose larval stages are closely coupled to the surface and hence may be particularly susceptible to pollution by oily slicks and films.

7. ZOOPLANKTON

Zooplankton are important components of the environment in terms of their biomass, their roles in the ecosystem, and their probable sensitivity to the kinds of petroleum industry development and transport activity anticipated in the Puget Sound region. Zooplankton are the major grazers of phytoplankton and as such are a critical tropic link between primary producers and carnivores, including commercially valuable fish. Many marine organisms are planktonic for their entire life cycle, but even organisms not usually thought of as plankton pass through early planktonic life stages. Most benthic and nektonic organisms have planktonic eggs and/or larval stages and are, therefore, especially vulnerable to contaminants throughout the water column (Moore et al., 1973).

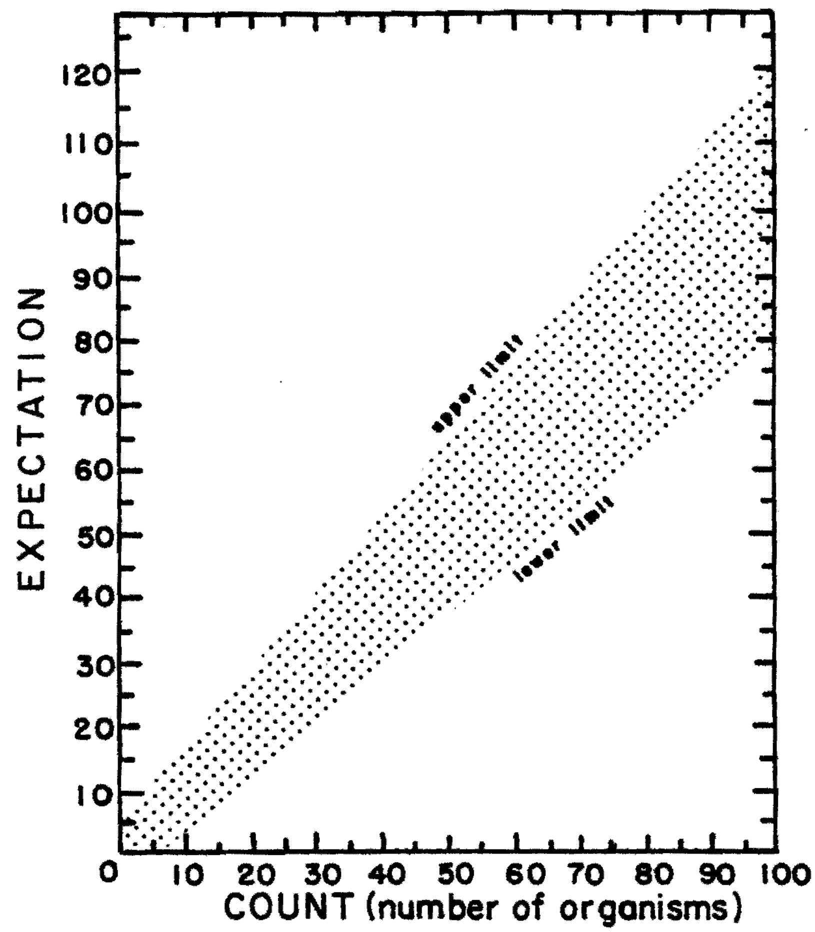

Figure 2. 95% of confidence intervals about phyto-plankton counts. For the confidence limits of a single count find the count on the horizontal axis and draw a vertical line through it. The limits are read off from the vertical axis at the points where this line cuts the upper and lower boundaries of the shaded zone. (Modified from Lund et al., 1958.)

In general, the distribution and particularly the vertical distribution of zooplankton is not narrowly fixed, but is subject to variations related to season, location, illumination, time, hydrographic conditions, and endogenous factors. Because of previous irregular space/time investigations, there is not much information on the dynamics of plankton populations within the Strait of Juan de Fuca, including seasonal cycles of species, species successions, recruitment, and vertical distributions and migrations of zooplankton. Much is known about the kinds of plankton organisms in the Strait of Juan de Fuca and, except for larval stages and a few large and important groups like cyclopoid copepods, the general taxonomic problems are manageable.

When compared to warm-water plankton, the fauna of the Strait of Juan de Fuca region is not particularly diverse. Nevertheless, one is dealing, in the net-zooplankton, with a community that undoubtedly comprises several hundred species, as both deep-water species from the North Pacific and those species usually associated with the Puget Sound environment inhabit this dynamic, transitional zone. Relatively few species might be treated as principal components, because of their numbers and mass, or because of their critical roles in the transfer and conversion of matter and energy within the ecosystem.

Zooplankton samples collected during the first four cruises in the Strait of Juan de Fuca have been processed and analyzed in the laboratory. Settled plankton volumes were used as an index of zooplankton biomass. An increasing trend in the plankton standing stock from the latter part of February through the month of June was observed (figs. 3 and 4). This pattern was reflected both in the results from the vertical tows (table 4) and in the data from oblique net-tows (table 5). The volumes determined from these two net-tow methods represent different size fractions of the plankton, with values from the vertical tows integrated over the entire water column, while the oblique tows provided volumes for the upper 50 m.

For any one cruise, only a few dissimilarities were readily apparent when settled volumes were compared between transects. For example, from the vertical hauls it can be seen that the highest concentration of plankton collected for any depth interval during February (SF7601) was in the deepest interval at station 8 (table 4). This value raised the concentration of plankton for the entire water column to several times the values found for stations 2 and 5. Also, at station 2 during late June (SF7604), plankton concentrations were found to be somewhat higher overall than at either station 5 or 8. However, these differences and other less conspicuous variations in the data can be attributed to irregularities in the time of sampling or to patchiness and other uncontrollable factors. Means of biomass from the oblique tows were quite uniform between transects (within cruises), and likewise indicated an increase in biomass with time (February-June) (fig. 4). Of additional interest and potential importance is that zooplankton volumes from the oblique tows on the Pillar Point transect (stations 4-6) were consistently as high and usually higher than volumes from the other two transects on each of the cruises during which samples were obtained from all three regions.

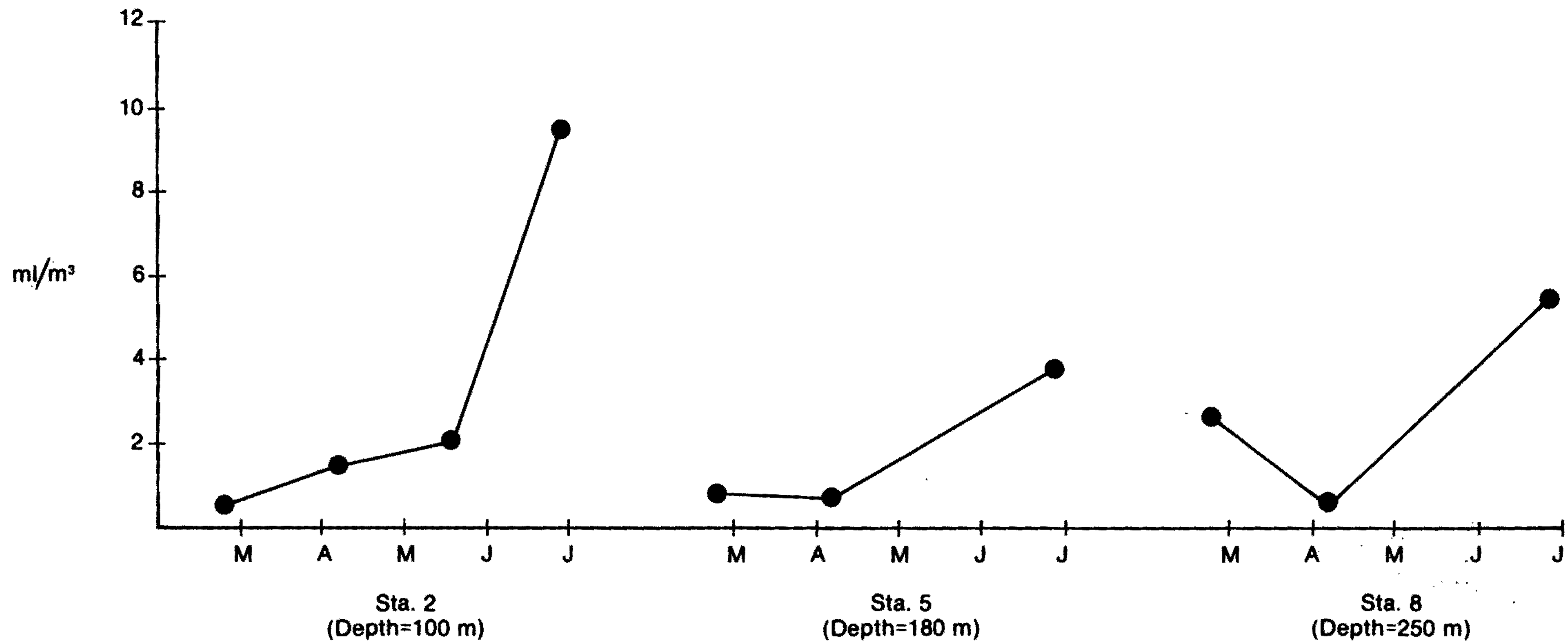

Figure 3. Zooplankton settled volumes. Vertical tows, 211-μm mesh size; total water column. Strait of Juan de Fuca, February-June 1976.

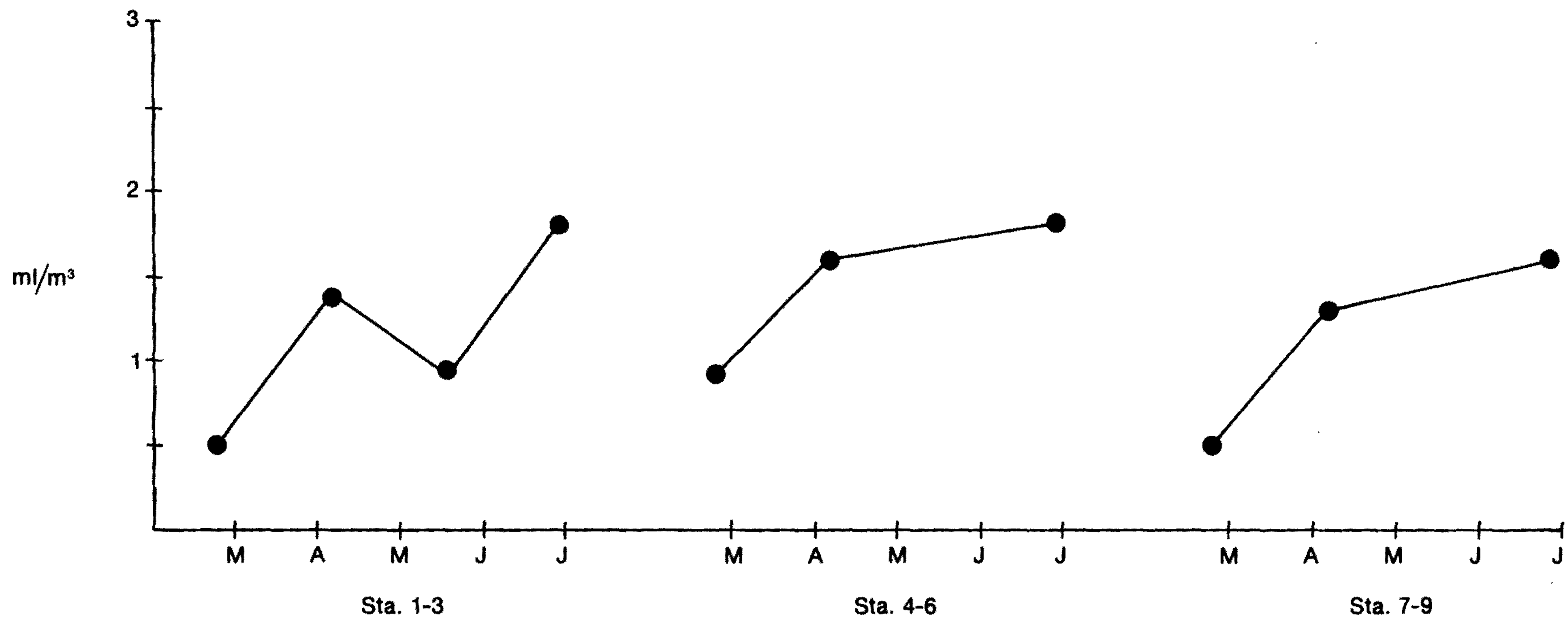

Figure 4. Zooplankton settled volumes, means of grouped stations. Bongo net, oblique tows (50-0 m), 333-μm mesh size. Strait of Juan de Fuca, February-June 1976.

Table 4. Zooplankton settled volumes (ml/m^3), vertical tows, 211-μm mesh size.

Cruise	Date	Interval Depth (m)	Station 2 Depth = 100 m	Station 5 Depth = 180 m	Station 8 Depth = 250 m
I	23-24 Feb 76	0-25	0.9	2.0	1.0
		25-50	1.0	2.4	1.1
		50-100	0.3	0.4	1.0
		100-bottom		0.7	3.2
II	5-6 Apr 76	0-25	2.9	1.3	1.3
		25-50	1.6	0.4	1.1
		50-100	0.8	0.7	0.8
		100-bottom		0.7	0.4
III	17-18 May 76	0-25	4.1		
		25-50	2.8		
		50-100	0.8		
		100-bottom			
IV	28-30 June 76	0-25	16.6	3.0	36.4
		25-50	9.4	7.4	1.9
		50-100	5.9	4.5	3.0
		100-bottom		3.2	3.4

Table 5. Zooplankton settled volumes (ml/m^3), oblique tows, 333-μm mesh size, 50-0 m.

Cruise	Date	Station No.								
		1	2	3	4	5	6	7	8	9
I	23-24 Feb 76	0.6	0.5	0.3	0.4	1.2	1.2		0.5	0.5
II	5-6 Apr 76	1.0	1.9	1.1	1.8	1.7	1.2	1.4	1.1	1.3
III	17-18 May 76	0.8	1.1	0.6						
IV	28-30 June 76	1.2	1.7	1.9	2.8	2.4	0.8	1.7	1.3	2.4

Zooplankton volumes are obtained relatively quickly and simply, but interpretations are complicated by the irregular occurrence of phytoplankton. Some phytoplankters form long intertwining chains and do not settle from the sample, but entangle zooplankton to give the appearance of a large plankton volume. Therefore, it is preferable to compare zooplankton of different times or areas by the kinds of plankton and their relative numerical abundance.

There was a substantial variety of taxonomic groups represented in these February-June samples. The most common groups were: Copepoda (by far the most numerous), Chaetognatha, Polychaeta, Medusae, Siphonophora, Cladocera, Ostracoda, Amphipoda, Euphausiacea, Decapoda, Tunicata, and larval fishes. See Appendix E for a list of species and major groups found.

The Copepoda of the Strait of Juan de Fuca were represented by about 50 species. The abundances and vertical distributions of some of the most significant species can be mentioned. These data are based on the average number of animals per m^3 in the water column at stations 2, 5, and 8.

The most abundant copepods were small near-surface and surface living calanoids *Pseudocalanus* spp. and *Acartia longiremis*, and the cyclopoid *Oithona similis* (tables 6-8). These animals can be present in high concentrations (hundreds to thousands/m^3) and probably play a key role in the conversion of plant material to animal substance. Moreover, they are an important food web link because of their high metabolic rates and energy turnover potential. Some other small, abundant copepods are more evenly distributed through the water column, or with perhaps minima at mid-depths: *Microcalanus* spp., *Oncaea borealis*, and juvenile *Pseudocalanus* spp. Of the larger, common species of copepods, *Calanus marshallae*, a key grazer (Frost, 1974), is usually most abundant in the deeper layers (table 9). Typically, *Calanus marshallae* would be expected to move into the surface layers at night, at which time its grazing influence would be significant.

Table 6. *Pseudocalanus* spp. (adults) numbers/m^3, vertical tows, 211-μm mesh size.

Cruise	Date	Interval Depth (m)	Station 2 Depth = 100 m	Station 5 Depth = 180 m	Station 8 Depth = 250 m
I	23-24 Feb 76	0-25	142.9	100.0	57.1
		25-50	82.1	110.7	207.1
		50-100	34.5	28.1	207.1
		100-bottom		4.2	105.0
II	5-6 Apr 76	0-25	629.0	279.0	343.0
		25-50	335.7	65.7	105.4
		50-100	141.7	29.9	80.4
		100-bottom		2.8	14.6
III	17-18 May 76	0-25	116.7		
		25-50	221.4		
		50-100	17.1		
		100-bottom			
IV	28-30 June 76	0-25	585.6	28.6	11.9
		25-50	542.9	385.7	57.1
		50-100	385.7	203.6	314.3
		100-bottom		202.4	273.5

Table 7. *Acartia longiremis* (adults) numbers/m^3, vertical tows, 211-μm mesh size.

Cruise	Date	Interval Depth (m)	Station 2 Depth = 100 m	Station 5 Depth = 180 m	Station 8 Depth = 250 m
I	23-24 Feb 76	0-25	33.9	21.4	7.1
		25-50	0.7	5.4	7.1
		50-100	0.5	5.4	0
		100-bottom		4.7	0
II	5-6 Apr 76	0-25	28.6	28.6	28.6
		25-50	28.6	0	0
		50-100	6.9	0.9	4.5
		100-bottom		0	0.3
III	17-18 May 76	0-25	41.7		
		25-50	33.3		
		50-100	1.8		
		100-bottom			
IV	28-30 June 76	0-25	14.3	14.3	7.1
		25-50	0	7.1	3.6
		50-100	21.4	10.7	28.6
		100-bottom		14.3	19.3

Table 8. _Oithona similis_ (adults) numbers/m^3, vertical tows, 211-μm mesh size.

Cruise	Date	Interval Depth (m)	Station 2 Depth = 100 m	Station 5 Depth = 180 m	Station 8 Depth = 250 m
I	23-24 Feb 76	0-25	30.4	50.0	214.3
		25-50	20.7	85.7	300.0
		50-100	9.3	46.9	175.0
		100-bottom		24.7	45.0
II	5-6 April 76	0-25	7.1	71.4	107.1
		25-50	0	18.6	67.8
		50-100	11.1	45.1	61.6
		100-bottom		14.6	7.4
III	17-18 May 76	0-25	25.0		
		25-50	0		
		50-100	2.7		
		100-bottom			
IV	28-30 June 76	0-25	28.6	10.7	0
		25-50	164.3	100.0	82.1
		50-100	60.7	71.4	114.3
		100-bottom		7.1	45.0

Table 9. _Calanus marshallae_ (adults) numbers/m^3, vertical tows, 211-μm mesh size.

Cruise	Date	Interval Depth (m)	Station 2 Depth = 100 m	Station 5 Depth = 180 m	Station 8 Depth = 250 m
I	23-24 Feb 76	0-25	5.4	3.6	7.1
		25-50	15.0	17.9	14.3
		50-100	9.8	11.1	17.9
		100-bottom		73.5	335.0
II	5-6 April 76	0-25	0	0	14.3
		25-50	0	5.7	39.2
		50-100	37.5	37.5	41.1
		100-bottom		46.5	32.1
III	17-18 May 76	0-25	8.3		
		25-50	21.4		
		50-100	2.1		
		100-bottom			
IV	28-30 June 76	0-25	0	7.1	2.3
		25-50	85.7	42.9	14.3
		50-100	14.3	3.6	50.0
		100-bottom		21.4	35.4

The temporal variability of these copepods reflects obvious interstation dissimilarities for individual species (figs. 5-8). These data are extremely difficult to interpret at this point, and demonstrate the complexity involved in evaluating plankton distribution and abundance and in determining possible consequences of environmental contaminants. For example, in late February, the zooplankton volumes were quite low at all stations sampled, and the large copepod Calanus marshallae was found in concentrations of almost 250/m^3 at station 8. Based on vertical net samples, this is almost seven times greater than concentrations found in late June when the total plankton biomass was highest for the 4-month period.

Euphausids were not nearly as abundant as copepods, but euphausids are a critical link between lower trophic levels and the large carnivores (Parsons and LeBrasseur, 1970). Three species were found: Euphausia pacifica, Thysanoessa longipes, and T. spinifera. The most numerous, Euphausia pacifica, was generally found at concentrations of less than 1/m^3 in late February, up to 9.2/m^3 at station 9 in early April, and reached 22.6/m^3 at station 2 in May (table 10). The data seem to suggest a maximum or near-maximum during May (SF7603), but the loss of the western transects at that time makes it difficult to generalize about the entire Strait. During Cruise IV, euphausid concentrations were again low.

Table 10. Euphausia pacifica numbers/m^3, oblique tows, 333-μm mesh size, 50-0 m.

Cruise	Date	Station No.								
		1	2	3	4	5	6	7	8	9
I	23-24 Feb 76	0.6	0.01	0.01	0.1	0.5	0.5		1.2	0.1
II	5-6 Apr 76	0	0	8.4	0	0	0.2	0.1	3.1	9.2
III	17-18 May 76	13.2	22.6	7.6						
IV	28-30 June 76	0	0.9	4.1	1.0	0.1	0	0	0	0

Only two species of chaetognath were identified, Sagitta elegans, the most abundant, and S. lyra. The concentration of Sagitta elegans fluctuated somewhat through the four cruises, with lower values (0.1-18.6/m^3) found during the cruises in late February and mid-May and higher values (8.5-68.2/m^3) recorded in early April and late June (table 11).

Several amphipods were collected, including Calliopius laeviusculus, Cyphocaris challengeri, Hyperoche medusarum, Parathemisto pacifica, and Primno macropa. While none was found to be present in great numbers, the most abundant, Parathemisto pacifica, was consistently found at values from 0.01-0.1/m^3 during Cruise I, virtually disappeared from samples during Cruises II and III, and finally was collected in relatively high numbers (0.02-19.7/m^3) in late June (table 12).

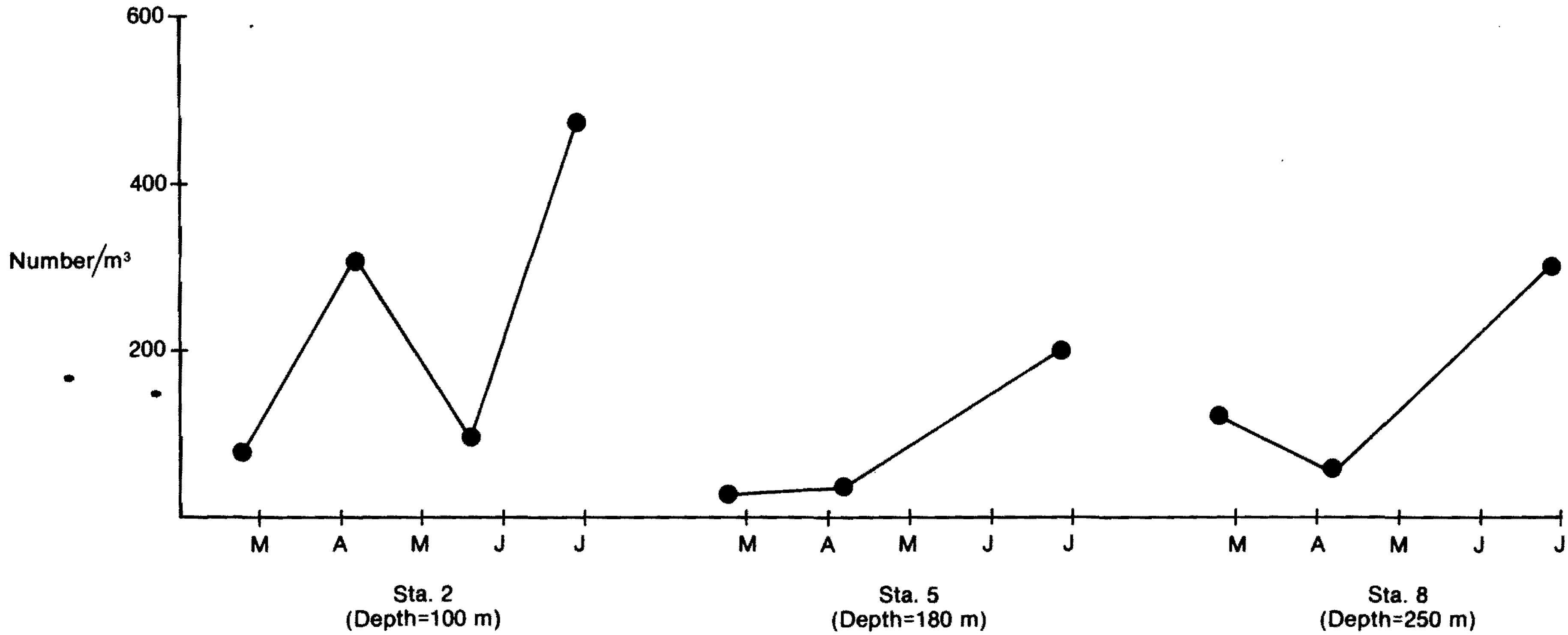

Figure 5. *Pseudocalanus* spp. (adults). Number of animals/m^3 in water column. Strait of Juan de Fuca, February-June 1976.

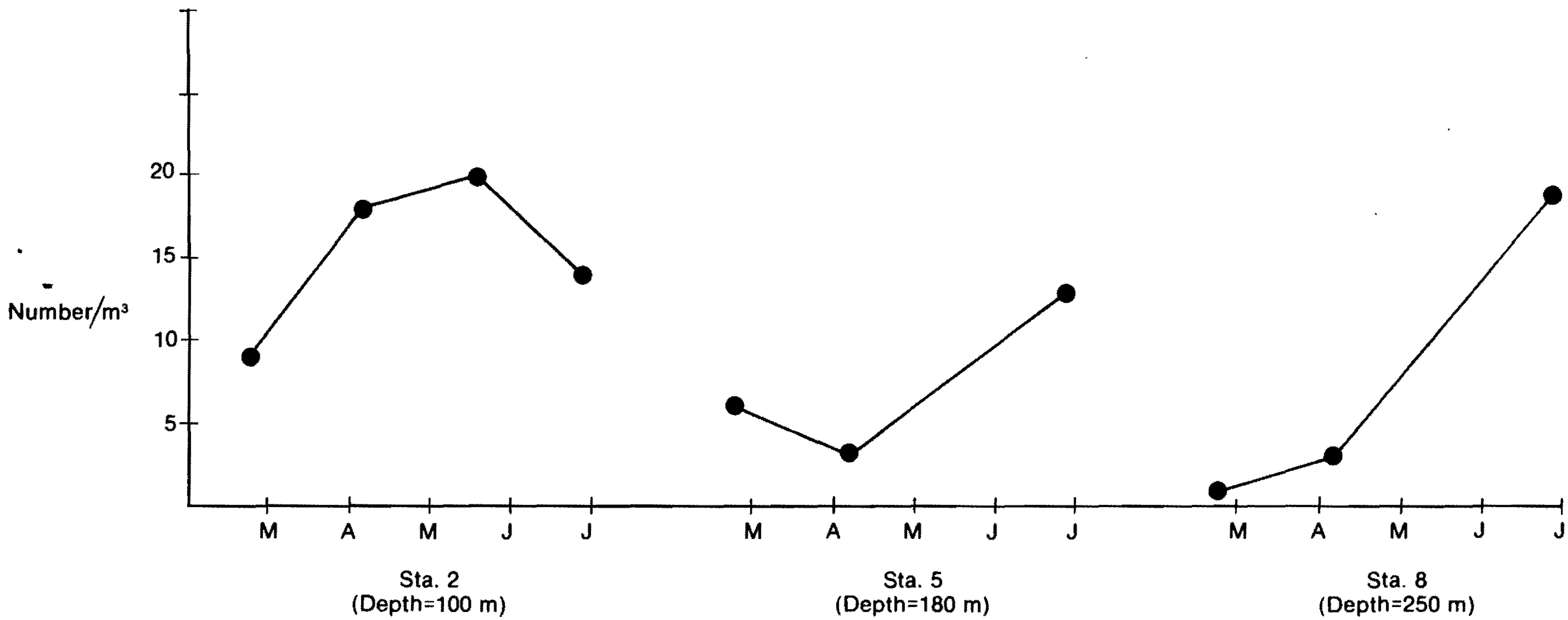

Figure 6. Acartia longiremis (adults). Number of animals/m^3 in water column. Strait of Juan de Fuca, February-June 1976.

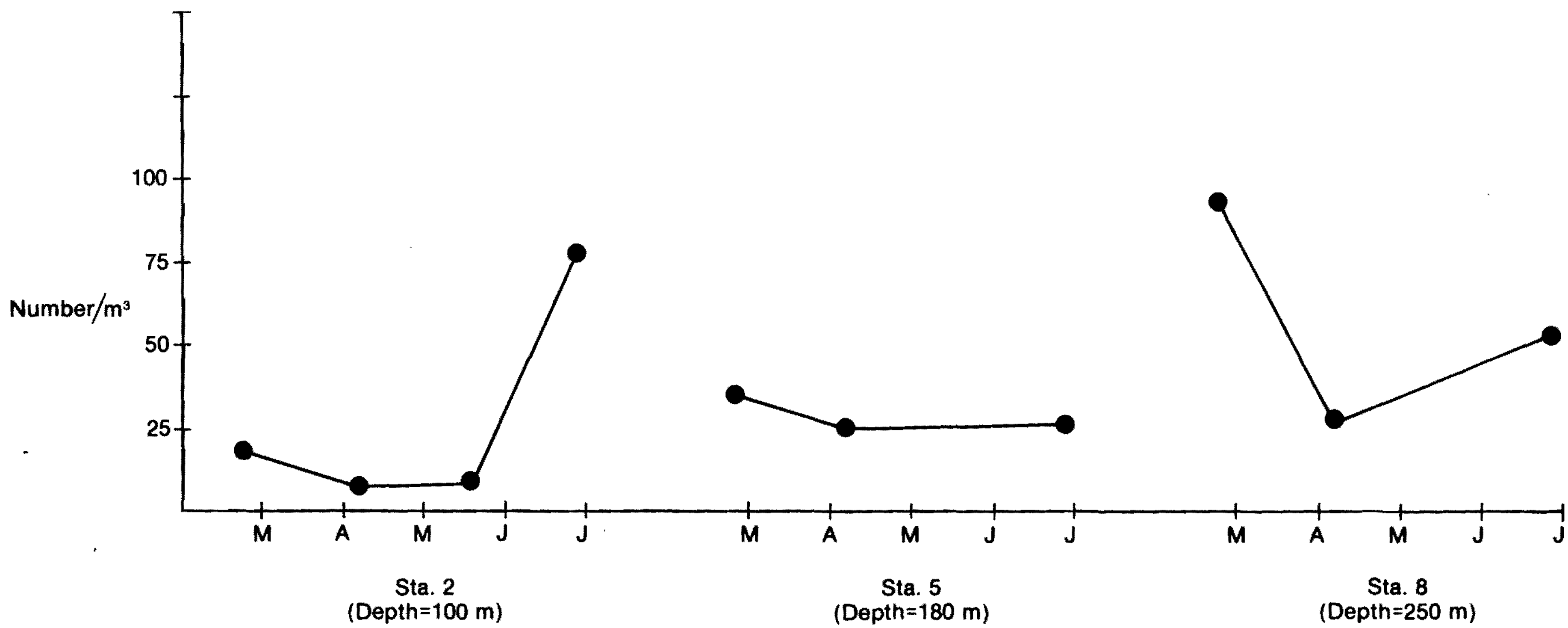

Figure 7. *Oithona similis* (adults). Number of animals/m^3 in water column. Strait of Juan de Fuca, February-June 1976.

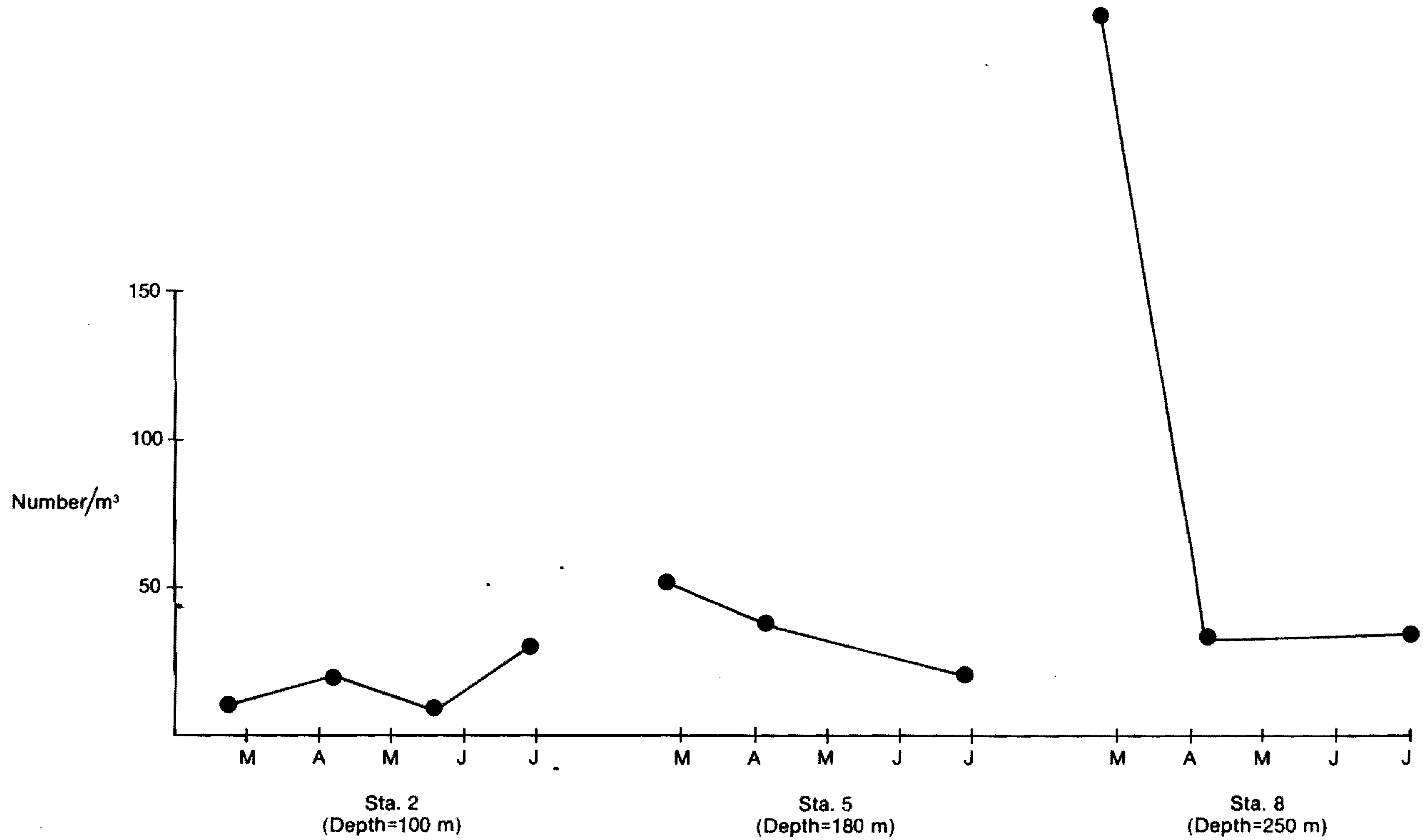

Figure 8. _Calanus marshallae_ (adults). Number of animals/m^3 in water column. Strait of Juan de Fuca, February-June 1976.

Table 11. Sagitta elegans number/m^3, oblique tows, 333-μm mesh size, 50-0 m.

Cruise	Date	Station No. 1	2	3	4	5	6	7	8	9
I	23-24 Feb 76	5.7	0.1	5.4	7.8	9.6	18.6		1.7	0.8
II	5-6 Apr 76	9.0	68.2	15.9	19.1	45.6	58.2	36.9	20.9	50.1
III	17-18 May 76	4.7	5.1	1.8						
IV	28-30 June 76	8.5	10.3	24.6	24.4	15.3	11.8	18.1	37.7	44.9

Table 12. Parathemisto pacifica numbers/m^3, oblique tows, 333-μm mesh size, 50-0 m.

Cruise	Date	Station No. 1	2	3	4	5	6	7	8	9
I	23-24 Feb 76	0.01	0.02	0.02	0.01	0.02	0.01		0.1	0.02
II	5-6 Apr 76	0.004	0	0	0	0	0	0	0	0
III	17-18 May 76	0	0	0						
IV	28-30 June 76	0	3.8	19.7	0.2	0.02	2.9	0	0.5	0.9

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APPENDIX A

TEMPERATURE, SALINITY, AND DENSITY DISTRIBUTION

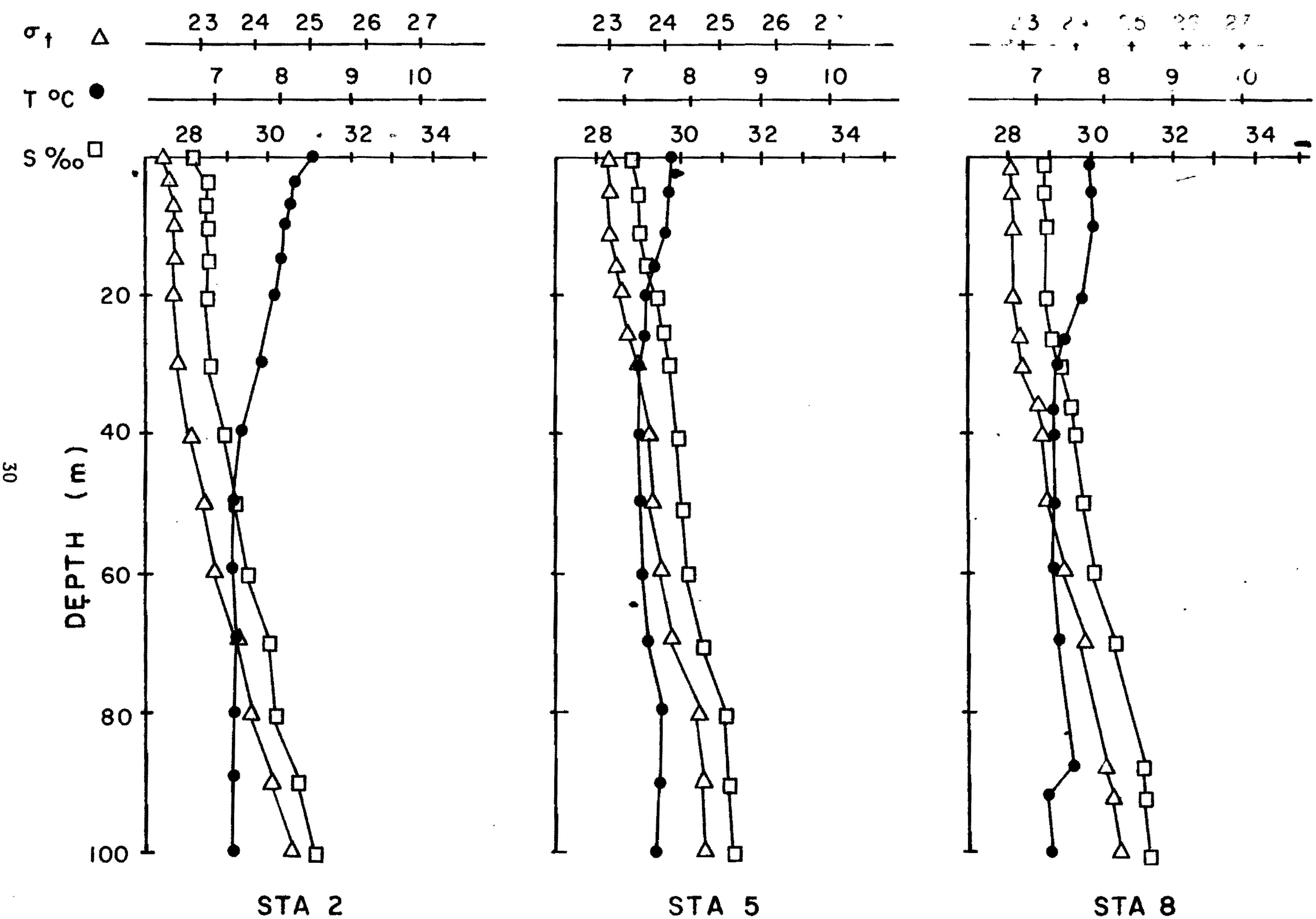


Figure A-1. Vertical distributions of salinity, temperature, and density during 5-6 April 1976 (SF7602).

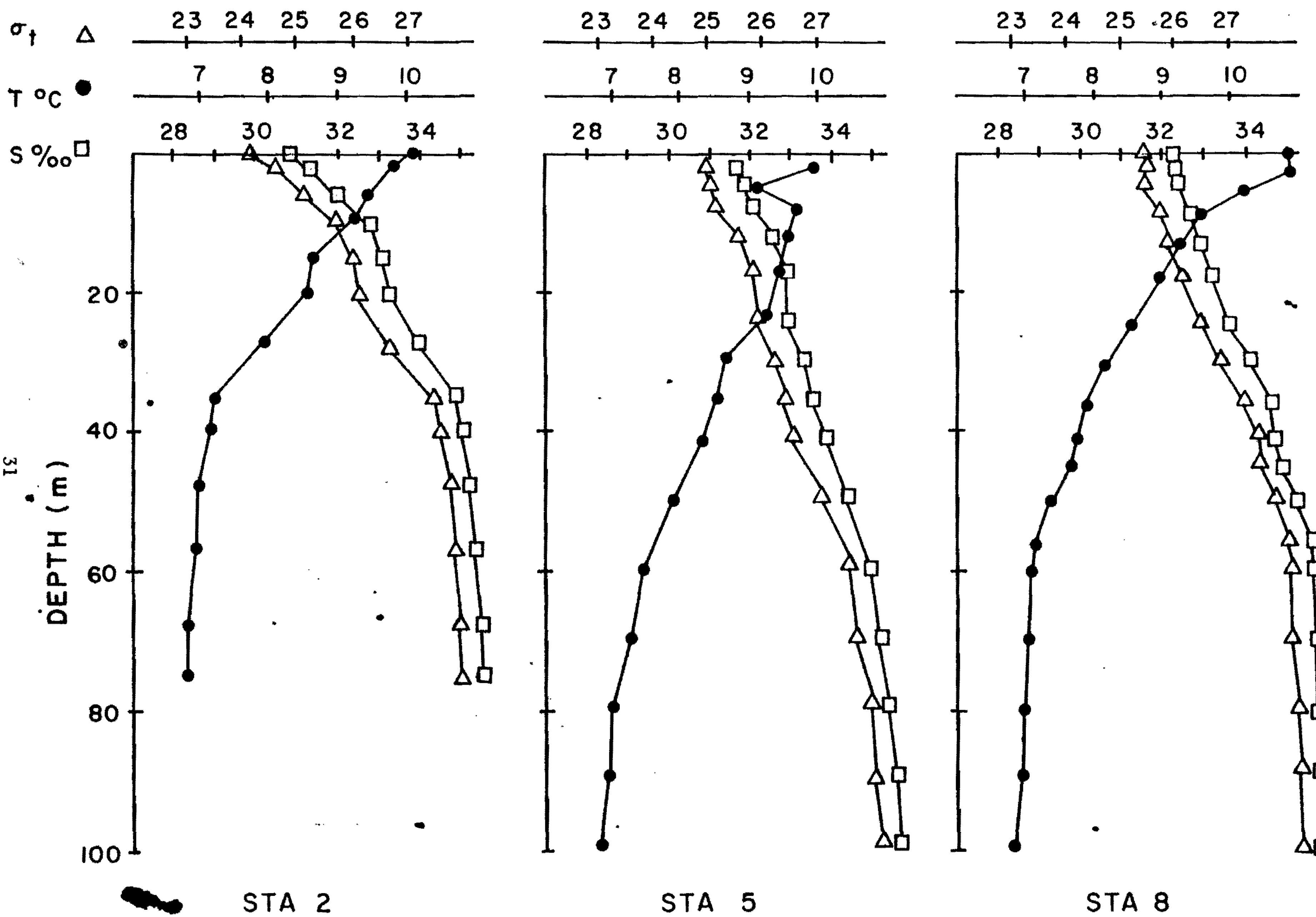


Figure A-2. Vertical distributions of salinity, temperature, and density during 28-30 June 1976 (SF7604).

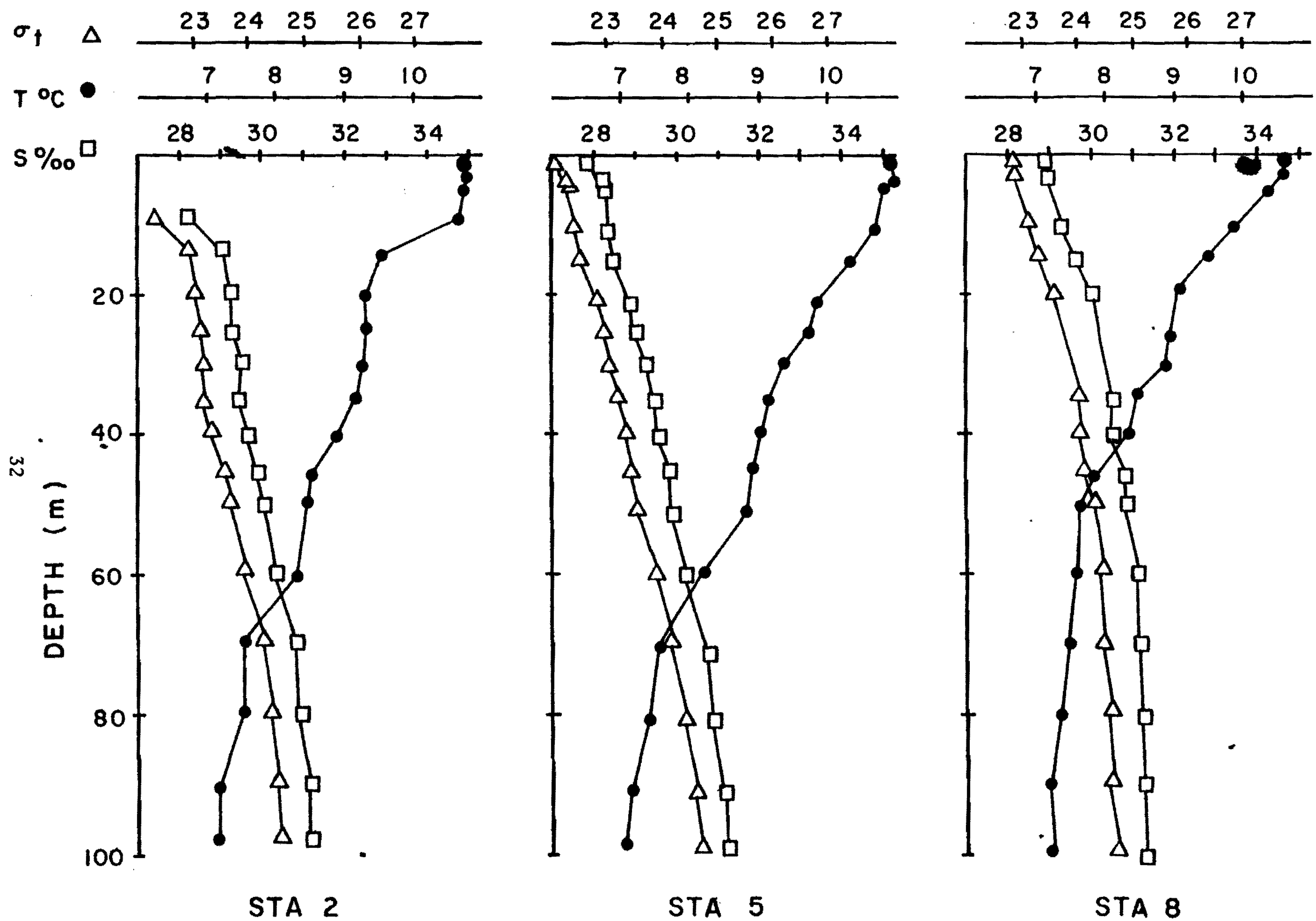


Figure A-3. Vertical distributions of salinity, temperature, and density during 3-5 August 1976 (SF7605).

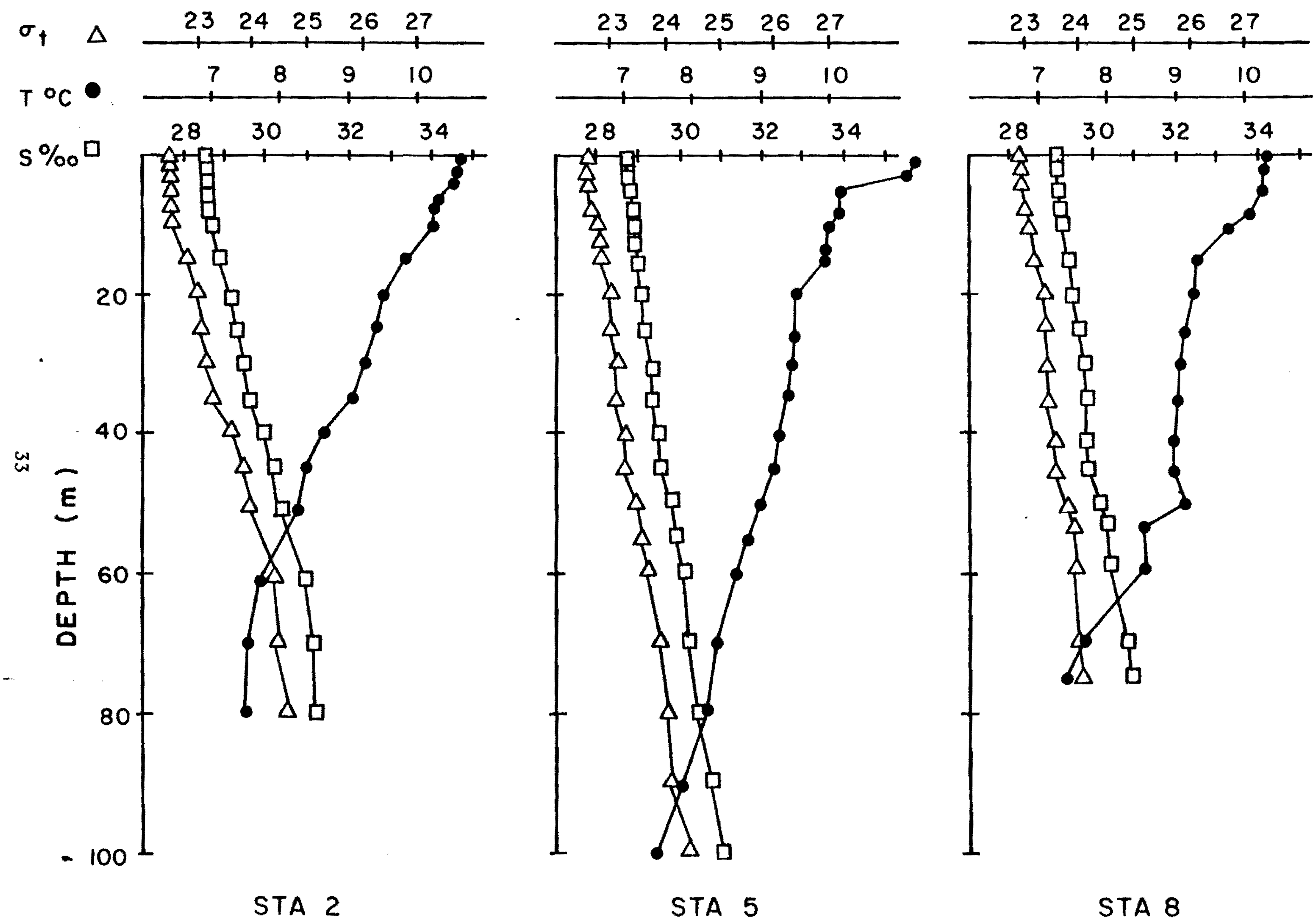


Figure A-4. Vertical distributions of salinity, temperature, and density during 14-16 September 1976 (SF7606).

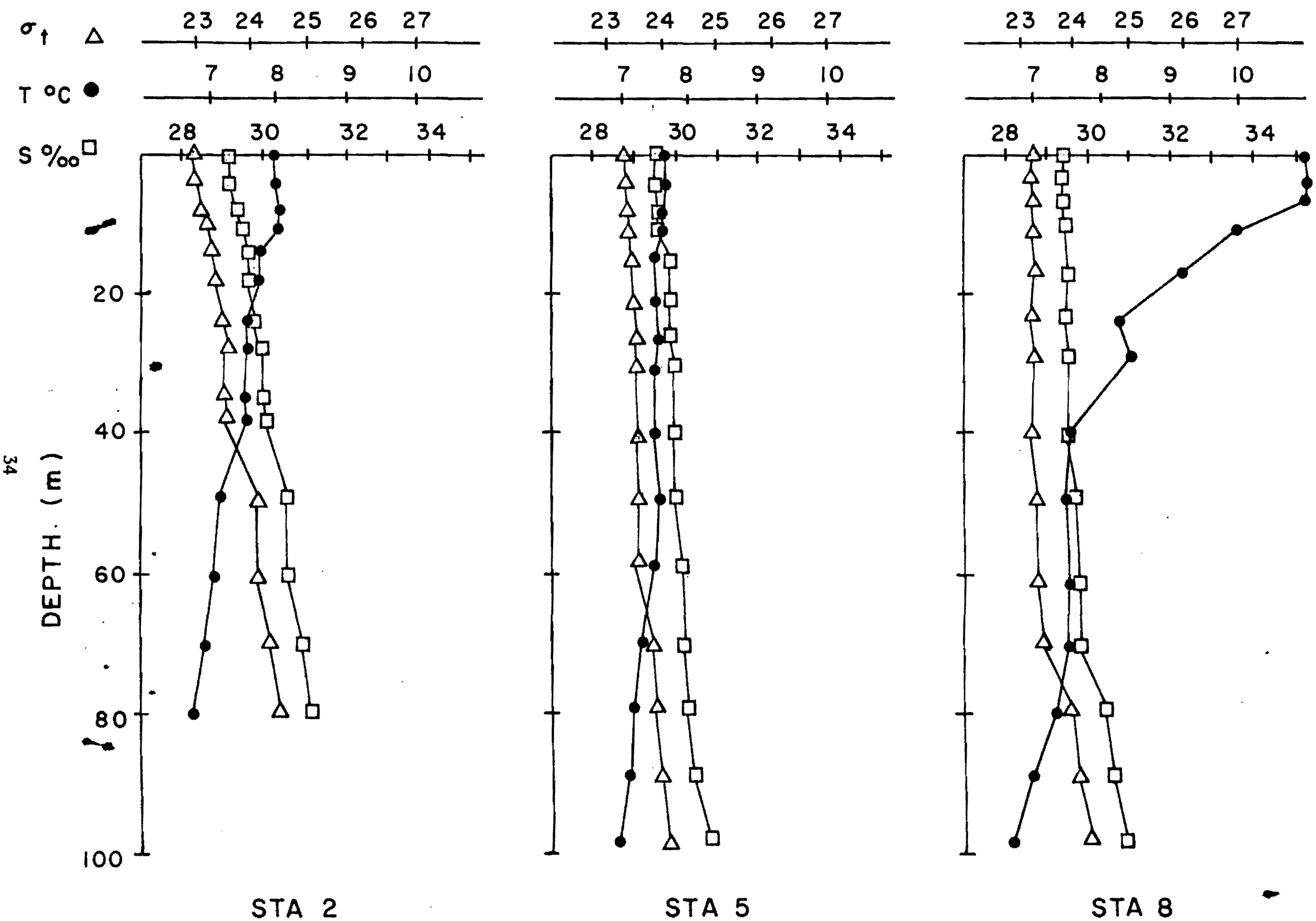


Figure A-5. Vertical distributions of salinity, temperature, and density during 12-15 November 1976 (SF7607).

APPENDIX B

PIGMENT DISTRIBUTIONS

Vertical distributions of chlorophyll *a* and pheopigment concentration for SF7601-SF7607 are presented in the following figures.

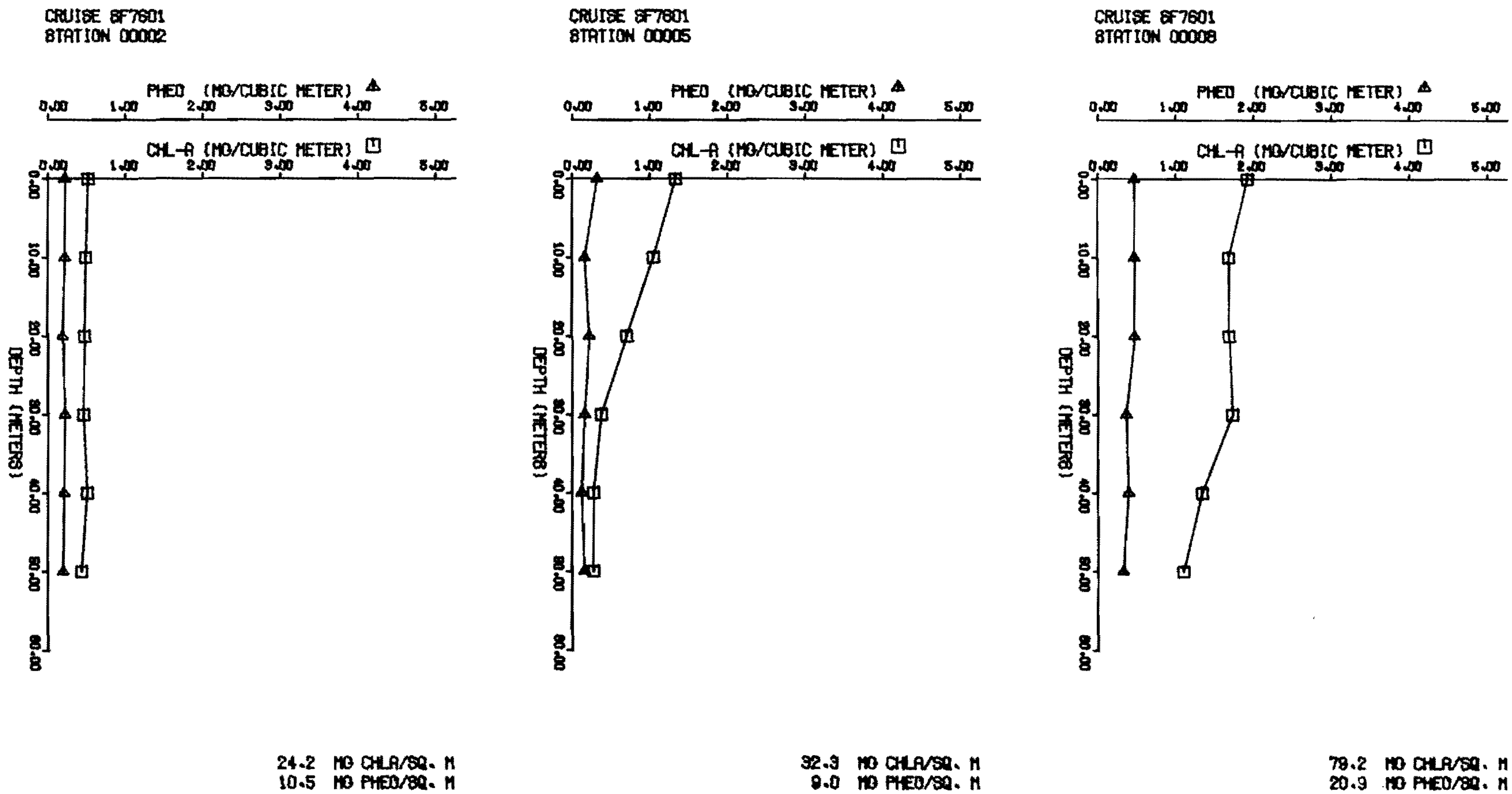
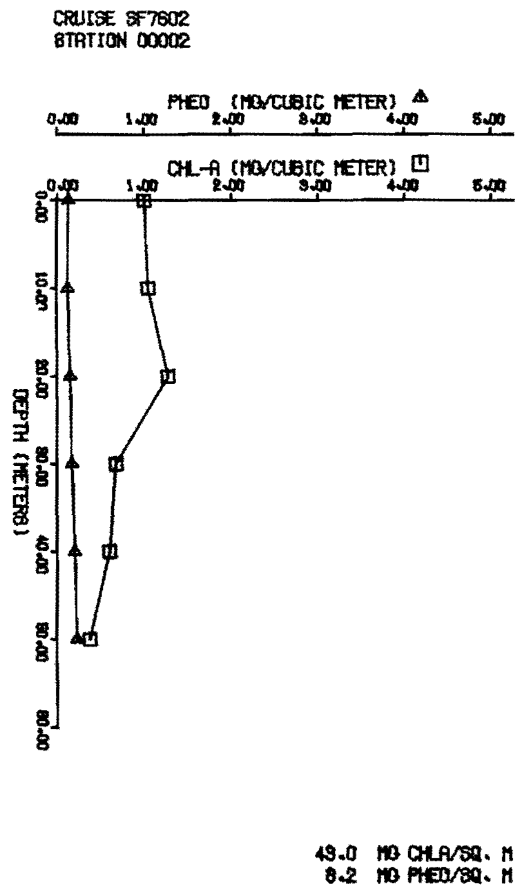
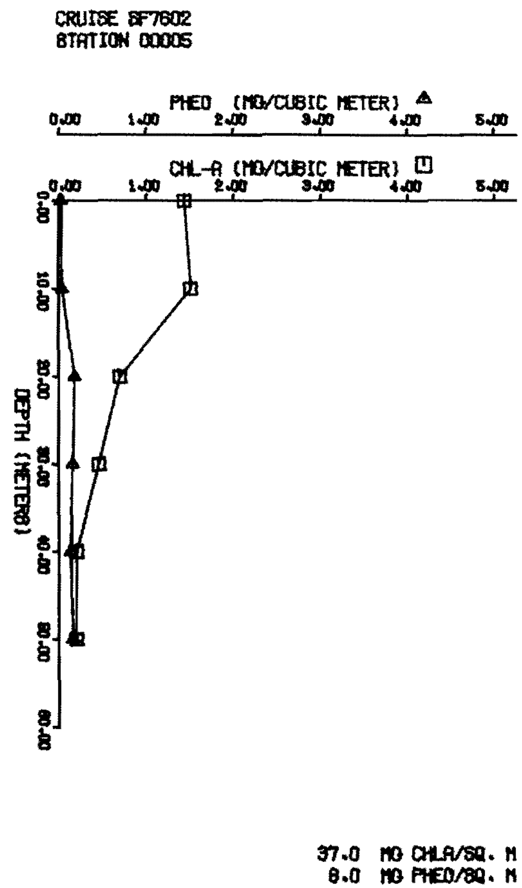


Figure B-1. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 23-24 February 1976.





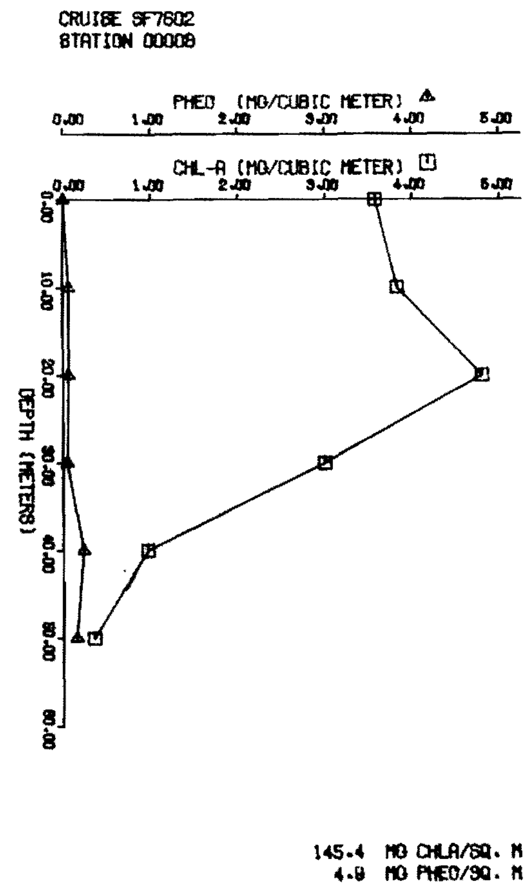


Figure B-2. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 5-6 April 1976.

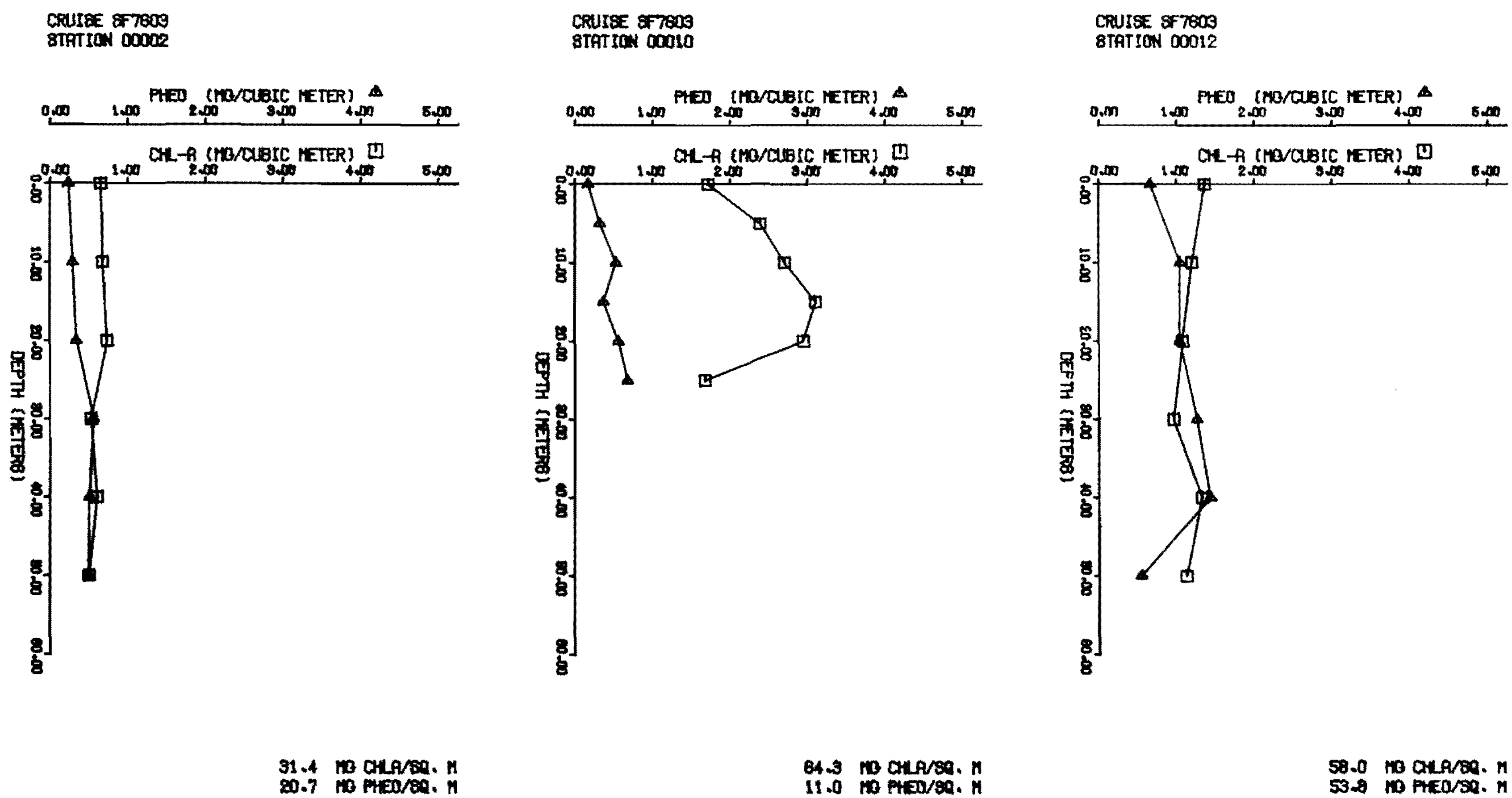


Figure B-3. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 17-18 May 1976.

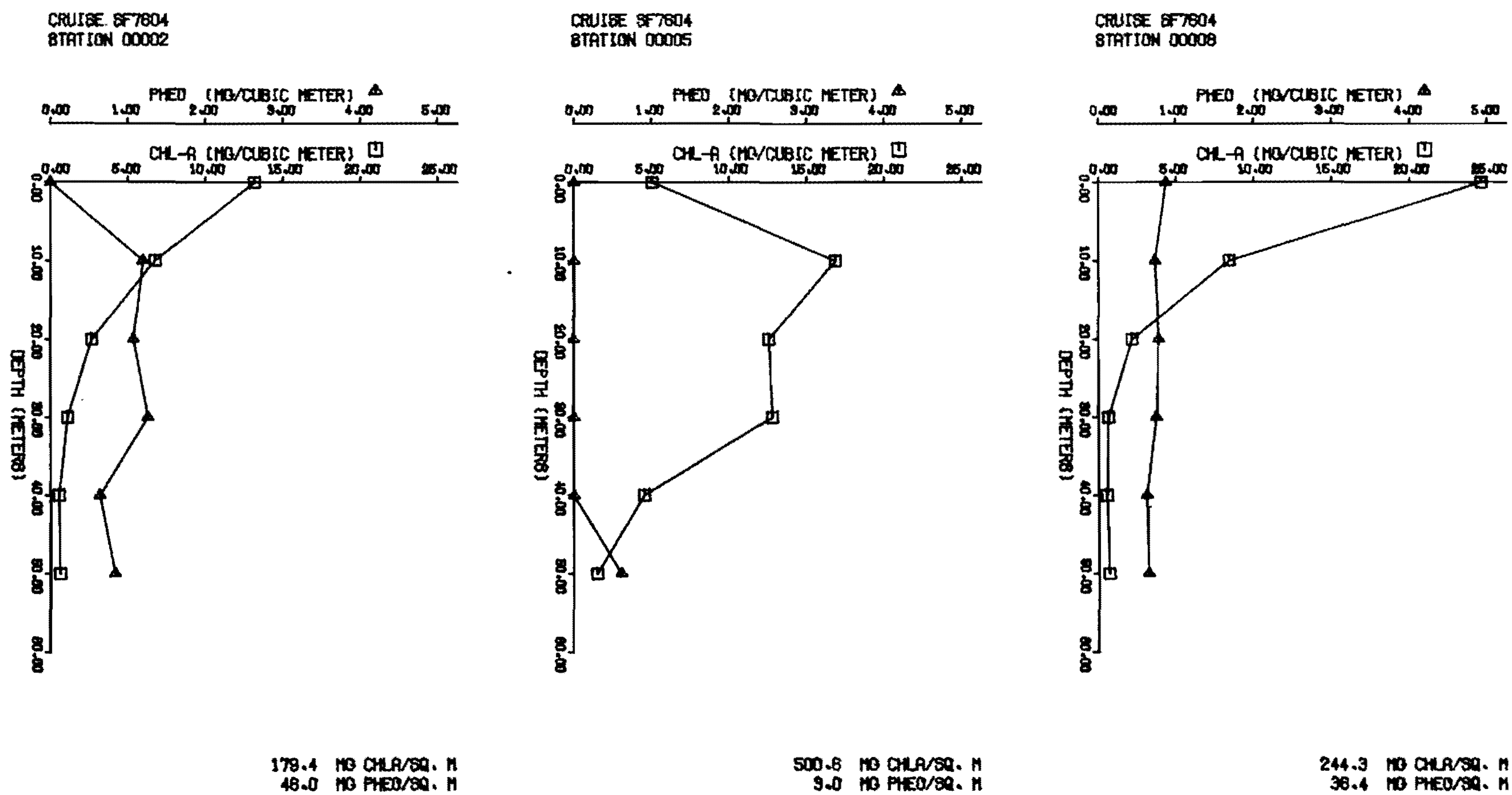


Figure B-4. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 28-30 June 1976.

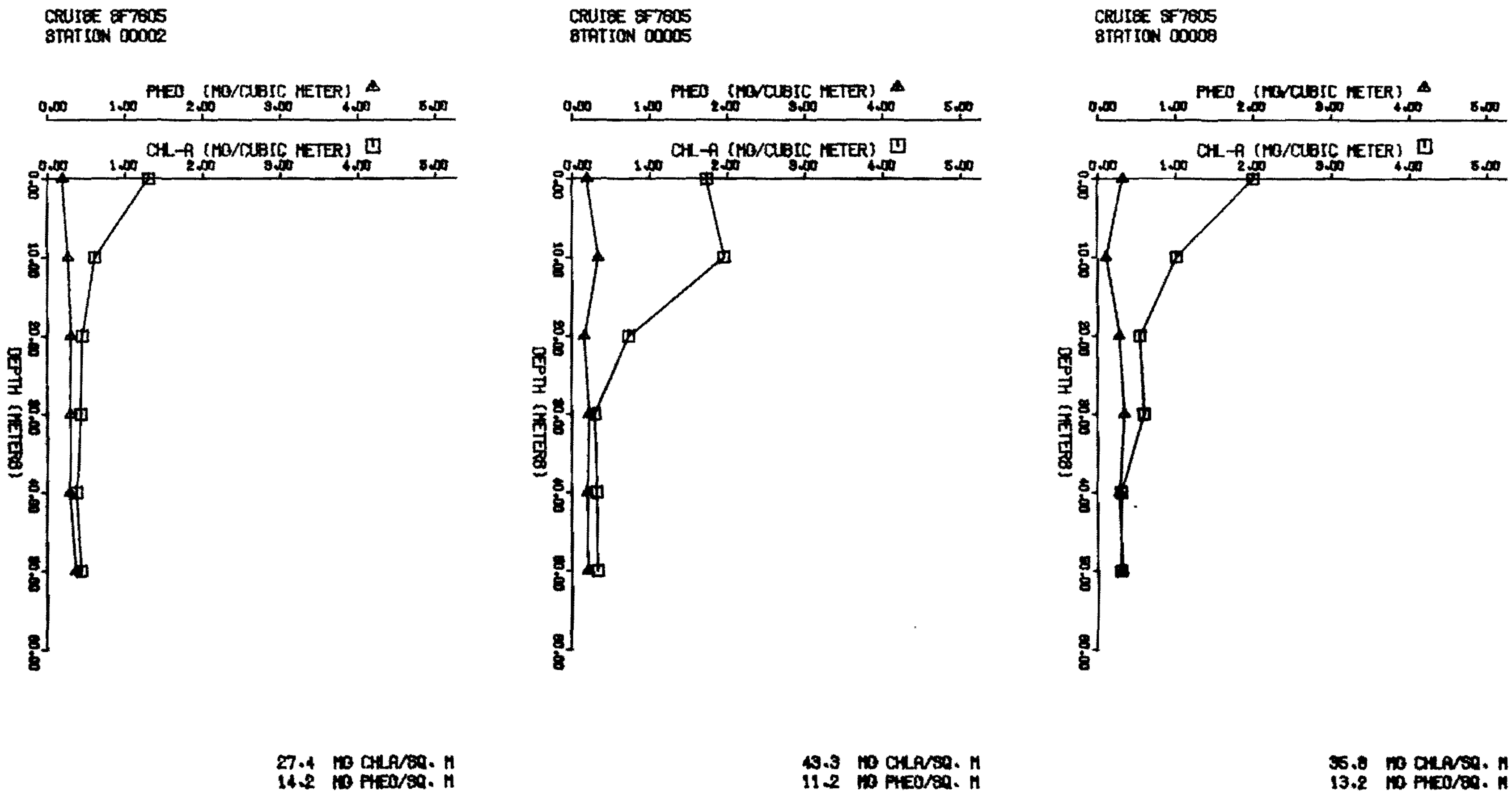


Figure B-5. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 3-5 August 1976.

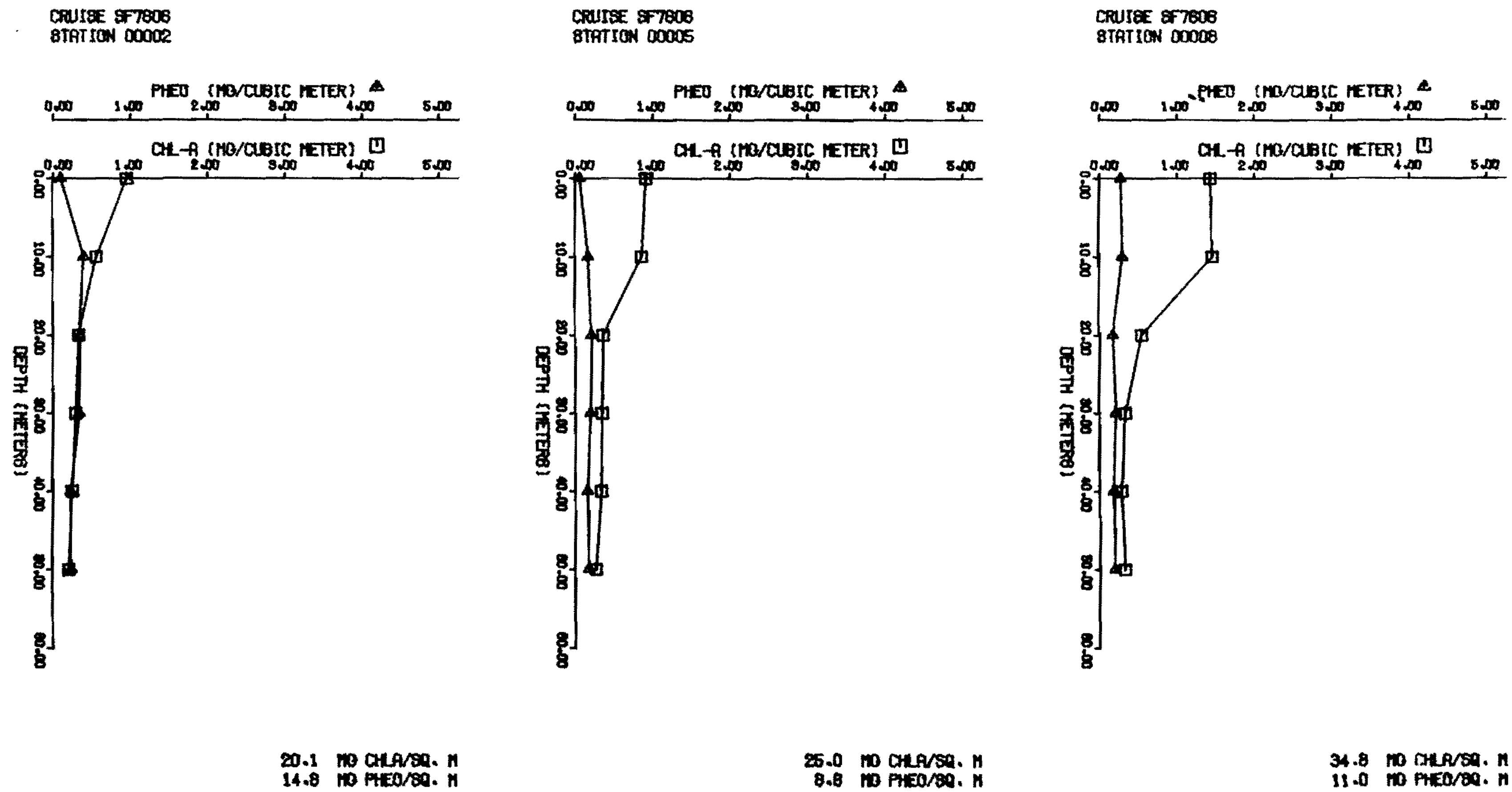


Figure B-6. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 14-16 September 1976.

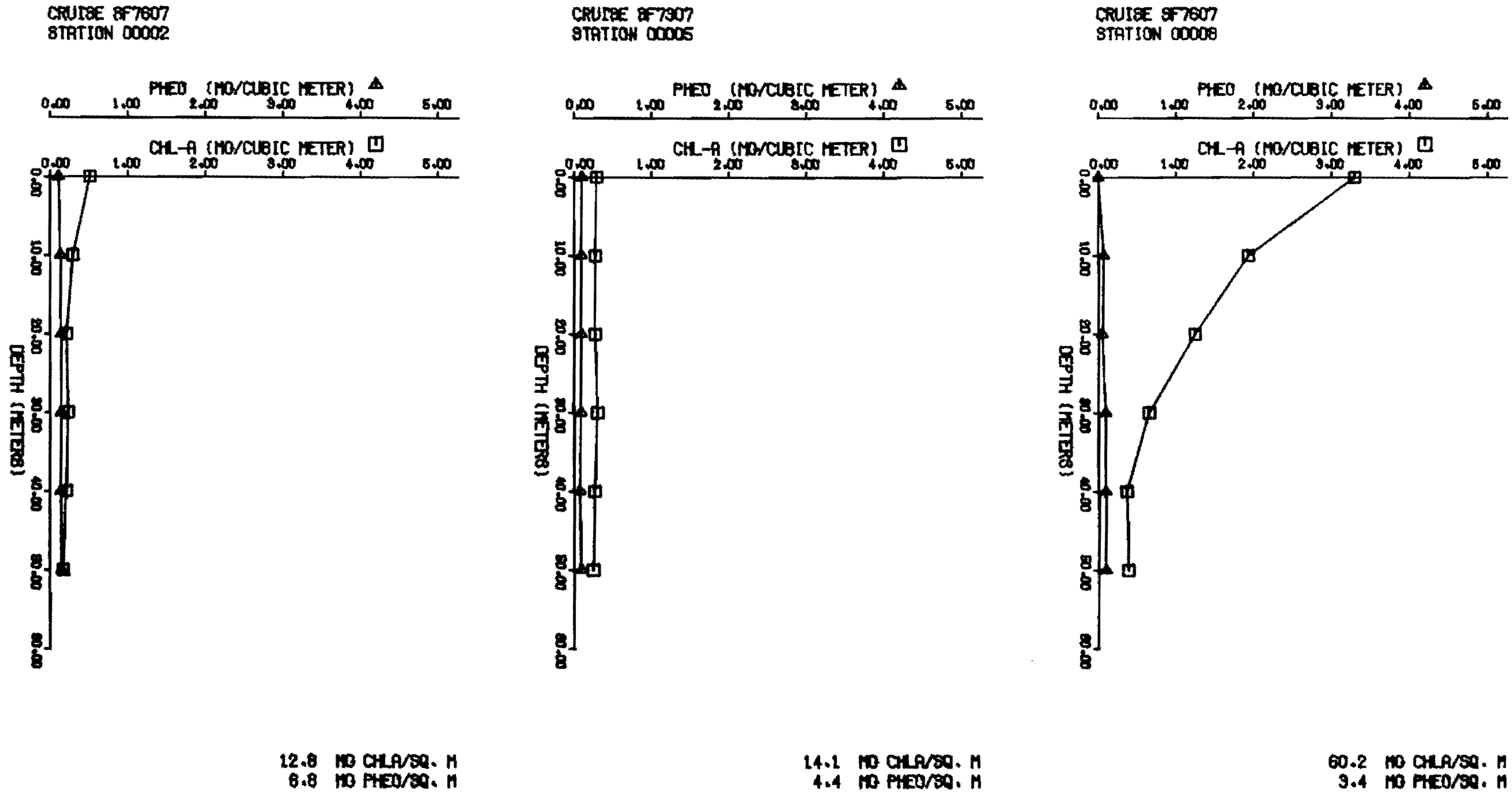


Figure B-7. Vertical distributions of chlorophyll a and pheopigment concentration (mg/m^3) during 12-15 November 1976.

APPENDIX C

TABULATED PHYTOPLANKTON DATA

CRUISE SF76C1	LAT 48-14 N	GMT DATE 02/24/76	
STATION 00002	LONG 123-22 W	GMT HOUR 0230	
		ZONE +08	

	(0M) CELLS/LITER	(50M) CELLS/LITER
BLUE-GREEN ALGAE		
MISCELLANEOUS BLUE-GREEN SPP.		1202
EUGLENOPHYTES		
MISCELLANEOUS EUGLENOIDS	67	
CHRYSOPHYTES		
DICTYOCHA FIBULA	84	
EBRIA TRIPARTITA	200	
COCCOLITHUS PELAGICUS	17	
DIATOMS		
AMPHIPRORA GIGANTEA V. SULCATA	17	
CHAETOCEROS GRACILIS	67	
COCCONEIS SPP.	17	
COSCINODISCUS EXCENTRICUS	33	
COSCINODISCUS LINEATUS	33	
DIPLONEIS SPP.	17	
FRAGILARIOPSIS SPP.	117	
LICMOPHORA SPP.	17	
MELOSIRA SULCATA	3340	1553
NITZSCHIA LONGISSIMA	234	
RHOICOSPHENIA CURVATA	17	
THALASSIONEMA NITZSCHIODES	84	
MISC. THALASSIOSIRA SPP.	768	
THALASSIOSIRA NORDENSKIOLDII	50	
DINOFLAGELLATES		
EXUVIELLA SPP.	17	
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	73296	2154

CRUISE SF7601 LAT 48-19 N GMT DATE 02/24/76
STATION 00005 LONG 124-06 W GMT HOUR 0830
ZONE +08

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	84	33
EBRIA TRIPARTITA	684	
PTEROSPERMA SP.		17
COCCOLITHUS PELAGICUS	17	33
DIATOMS		
FRAGILARICPSIS SPP.	284	
MELOSIRA SULCATA	217	818
NITZSCHIA LONGISSIMA	167	84
RHIZOSOLENIA SETIGERA	584	
THALASSIONEMA NITZSCHIODES		84
MISC. THALASSIOSIRA SPP.	2772	284
MISC. PENNATE DIATOMS		33
DINOFLAGELLATES		
GYMNODINIUM LOHMANNI	17	
EXUVIELLA SPP.	985	
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	79960	8484

CRUISE SF7601	LAT 48-27 N	GMT DATE 02/24/76
STATION 00008	LONG 124-37 W	GMT HOUR 1430
		ZONE +08

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	67	40
EBRIA TRIPARTITA	1232	1120
MISC. COCCOLITHOPHORID SPP.	3197	
PTEROSPERMA SP.		40
COCCOLITHUS PELAGICUS	166	320
DIATOMS		
CHAETOCEROS CONCAVICORNIS		240
MISC. COSCINODISCUS SPP.		40
COSCINODISCUS EXCENTRICUS	33	
COSCINODISCUS LINEATUS	2	80
COSCINODISCUS STELLARIS	33	
FRAGILARIOPSIS SPP.	266	360
MELOSIRA SULCATA		120
NITZSCHIA LONGISSIMA	166	80
THALASSIONEMA NITZSCHIODES	266	
MISC. THALASSIOSIRA SPP.	4729	5160
MISC. PENNATE DIATOMS	33	40
DINOFLAGELLATES		
EXUVIELLA SPP.	2398	
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	23844	73981

CRUISE SF7602 LAT 48-14 N GMT DATE 04/06/76
STATION 00002 LONG 123-22 W GMT HOUR 2350
ZONE +08

	(0M) CELLS/LITER	(50M) CELLS/LITER
EUGLENOPHYTES		
MISCELLANEOUS EUGLENOIDS	366	30
CHRYSOPHYTES		
DICTYOCHA FIBULA	233	
EBRIA TRIPARTITA	433	100
DIATOMS		
CHAETOCEROS GRACILIS	67	
MISC. COSCINODISCUS SPP.		10
FRAGILARIOPSIS SPP.	133	110
MELOSIRA SULCATA		1810
NITZSCHIA LONGISSIMA	300	210
THALASSIONEMA NITZSCHIODES	233	100
MISC. THALASSIOSIRA SPP.	2564	1570
MISC. PENNATE DIATOMS		10
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	128881	2740

CRUISE SF7602 LAT 48-19 N GMT DATE 04/06/76
STATION 00005 LONG 124-06 W GMT HOUR 1735
ZONE +08

	(0M) CELLS/LITER	(50M) CELLS/LITER
EUGLENOPHYTES		
MISCELLANEOUS EUGLENOIDS	670	
CHRYSOPHYTES		
MISC. CHRYSOPHYTE SPP.	166	
DICTYOCHA FIBULA	200	
EBRIA TRIPARTITA	700	
MISC. COCCOLITHOPHORID SPP.	33	
COCCOLITHUS PELAGICUS		50
DIATOMS		
MISC. HYALOCHAETE CHAET. SPP.		33
MISC. COSCINODISCUS SPP.	67	
FRAGILARIOPSIS SPP.	866	
MELOSIRA SULCATA	1798	1269
NITZSCHIA LONGISSIMA	633	150
THALASSIONEMA NITZSCHIODES	433	134
MISC. THALASSIOSIRA SPP.	3164	1667
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	146154	3023

CRUISE SF7602 LAT 48-28 N GMT DATE 04/06/76
STATION 00008 LONG 124-40 W GMT HOUR 0500
ZONE +08

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	932	100
EBRIA TRIPARTITA	1865	100
COCCOLITHUS PELAGICUS		100
DIATOMS		
MISC. HYALOCHAETE CHAET. SPP.	266	
CHAETOCEROS GRACILIS		33
FRAGILARIOPSIS SPP.	3330	300
MELOSIRA SULCATA		1232
NITZSCHIA LONGISSIMA	2930	733
SKELETONEMA COSTATUM	1465	333
THALASSIONEMA NITZSCHIOIDES	9724	400
MISC. THALASSIOSIRA SPP.	40892	3297
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	365384	9352

CRUISE SF7603 LAT 48-14 N GMT DATE 05/18/76
STATION 00002 LONG 123-22 W GMT HOUR 0215
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
EUGLENOPHYTES		
MISCELLANEOUS EUGLENOIDS	700	51
CHRYSOPHYTES		
EBRIA TRIPARTITA	67	
DIATOMS		
MISC. HYALOCHAETE CHAET. SPP.		501
CHAETOCEROS GRACILIS	167	100
CHAETOCEROS RADICANS		134
COSCINODISCUS EXCENTRICUS	67	150
COSCINODISCUS LINEATUS	33	
COSCINODISCUS MARGINATUS		17
DITYLUM BRIGHTWELLII	33	17
GRAMMATOPHORA SPP.	67	
LEPTOCYLINDRUS DANICUS	100	67
MELOSIRA SULCATA	2705	2505
NITZSCHIA DELICATISSIMA		100
NITZSCHIA LONGISSIMA	434	250
NITZSCHIA SERIATA	300	
RHIZOSOLENIA SETIGERA		51
SKELETONEMA COSTATUM	3474	5528
THALASSIONEMA NITZSCHIODES	1102	2238
MISC. THALASSIOSIRA SPP.		2488
THALASSIOSIRA AESTIVALIS		3503
THALASSIOSIRA DECIPIENS	67	367
THALASSIOSIRA NORDENSKIOLDII	100	367
THALASSIOSIRA PACIFICA	333	
THALASSIOSIRA POLYCHORDA		33
MISC. CENTRIC DIATOMS		33
DINOFLAGELLATES		
AMPHIDINIUM SPP.		7
PERIDINIUM CERASUS	100	
PERIDINIUM MINISCULUM	33	
PERIDINIALES	134	33
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	10755	1219

CRUISE SF7604 LAT 48-14 N GMT DATE 06/29/76
STATION 00002 LONG 123-22 W GMT HOUR 0055
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
GREEN ALGAE		
MISCELLANEOUS GREEN SPP.	600	
CHRYSOPHYTES		
MISC. CHRYSOPHYTE SPP.	200	
DIATOMS		
ASTERIONELLA JAPONICA	4200	50
MISC. HYALOCHAETE CHAET. SPP.	32000	1500
CHAETOCEROS AFFINIS		133
CHAETOCEROS BREVIS	6800	33
CHAETOCEROS COMPRESSUS		617
CHAETOCEROS CONCAVICORNIS		33
CHAETOCEROS CONSTRICTUS		250
CHAETOCEROS DEBILIS	13400	834
CHAETOCEROS DECIPIENS	3600	167
CHAETOCEROS DIDYMUS	3200	
CHAETOCEROS RADICANS	3800	517
CHAETOCEROS SIMILIS	8600	600
CORETHRON HYSTRIX	600	
COSCINODISCUS MARGINATUS		17
DITYLUM BRIGHTWELLII		17
MELOSIRA SULCATA	1200	2250
NITZSCHIA SPP.		333
NITZSCHIA DELICATISSIMA	1000	67
NITZSCHIA LONGISSIMA	600	67
NITZSCHIA PUNGENS	1800	
RHIZOSOLENIA SETIGERA		17
SKELETONEMA COSTATUM	1142400	78268
THALASSIONEMA NITZSCHIODES	1600	733
MISC. THALASSIOSIRA SPP.	7200	550
THALASSIOSIRA AESTIVALIS	3400	233
THALASSIOSIRA CONDENSATA	3200	200
THALASSIOSIRA DECIPIENS	2000	117
THALASSIOSIRA NORDENSKIOLDII	16000	433
THALASSIOSIRA PACIFICA		33
THALASSIOSIRA ROTULA	4400	717
DINOFLAGELLATES		
AMPHIDINIUM SPP.	200	
DINOPHYSIS SPP.		17
PERIDINIUM SPP.		17
EXUVIELLA SPP.		33
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	27800	2000

CRUISE SF7604 LAT 48-19 N GMT DATE 06/29/76
STATION 00005 LONG 124-06 W GMT HOUR 1720
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
EBRIA TRIPARTITA	40	
DIATOMS		
ASTERIONELLA JAPONICA	1360	266
BIDDULPHIA AURITA		633
MISC. HYALOCHAETE CHAET. SPP.	6200	7298
CHAETOCEROS COMPRESSUS	3160	133
CHAETOCEROS CONSTRICTUS	1560	
CHAETOCEROS DEBILIS	4120	2131
CHAETOCEROS DECIPIENS	360	
CHAETOCEROS DIDYMUS	120	
CHAETOCEROS RADICANS	1560	2231
CHAETOCEROS SIMILIS	1240	1798
COCCONEIS SCUTELLUM	40	
MISC. COSCINODISCUS SPP.	40	
COSCINODISCUS EXCENTRICUS		100
COSCINODISCUS LINEATUS		67
DITYLUM BRIGHTWELLII	40	
MELOSIRA SULCATA		599
NITZSCHIA SPP.	3200	1332
NITZSCHIA LONGISSIMA	840	
RHIZOSOLENIA SPP.	120	33
RHIZOSOLENIA SETIGERA		100
SKELETONEMA COSTATUM	25000	81951
STEPHANOPYXIS NIPPONICA		67
THALASSIONEMA NITZSCHIODES	840	1498
MISC. THALASSIOSIRA SPP.	1640	2897
THALASSIOSIRA AESTIVALIS	480	1732
THALASSIOSIRA DECIPIENS	2000	
THALASSIOSIRA NORDENSKIOLDII	3360	4995
THALASSIOSIRA PACIFICA		533
THALASSIOSIRA ROTULA	320	2131
MISC. PENNATE DIATOMS	40	
DINOFLAGELLATES		
MISC. DINOFLAGELLATES	200	
DINOPHYSIS SPP.	40	
PERIDINIUM SPP.	320	
PERIDINIUM MINISCULUM	80	
PERIDINIALES		166
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	15560	

CRUISE SF76C4	LAT 48-28 N	GMT DATE 06/29/76	
STATION 00C08	LONG 124-40 W	GMT HOUR 2330	
		ZONE +07	

	(0M) CELLS/LITER	(50M) CELLS/LITER
EUGLENOPHYTES		
MISCELLANEOUS EUGLENOIDS	2000	
CHRYSOPHYTES		
DICTYOCHA FIBULA	1600	
DIATOMS		
ASTERIONELLA JAPONICA	31200	300
MISC. HYALOCHAETE CHAET. SPP.	30000	4234
CHAETOCEROS AFFINIS	16000	
CHAETOCEROS COMPRESSUS	66000	67
CHAETOCEROS CONSTRICTUS	44800	133
CHAETOCEROS DEBILIS		317
CHAETOCEROS DECIPIENS	32800	200
CHAETOCEROS DIDYMUS	7600	
CHAETOCEROS RADICANS	34000	350
CHAETOCEROS SIMILIS	28800	283
CHAETOCEROS TORTISSIMUS	18400	
CORETHRON HYSTRIX		17
MELOSIRA SULCATA		367
NAVICULA SPP.		17
NITZSCHIA SPP.	66400	717
NITZSCHIA DELICATISSIMA		233
NITZSCHIA LONGISSIMA	16800	33
SKELETONEMA COSTATUM	1010000	
STEPHANOPYXIS NIPPONICA	1600	
THALASSIONEMA NITZSCHIODES	6800	533
MISC. THALASSIOSIRA SPP.	7600	150
THALASSIOSIRA AESTIVALIS		450
THALASSIOSIRA CONDENSATA		217
THALASSIOSIRA DECIPIENS	62800	33
THALASSIOSIRA NORDENSKIOLDII	110400	1000
THALASSIOSIRA PACIFICA		2321
THALASSIOSIRA ROTULA	11600	200
THALASSIOSIRA POLYCHORDA	800	
MISC. PENNATE DIATOMS	1600	
DINOFLAGELLATES		
MISC. DINOFLAGELLATES	94400	
DINOPHYSIS SPP.	400	
GYMNODINIUM SPP.	3200	
PERIDINIUM SPP.	14000	50
PERIDINIUM MINISCULUM	400	
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	432000	2034

CRUISE SF7605 LAT 48-14 N GMT DATE 08/03/76
STATION 00002 LONG 123-22 W GMT HOUR 2359
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
EBRIA TRIPARTITA	33	10
DIATOMS		
ASTERIONELLA JAPONICA		10
BIDDULPHIA LONGICRURIS		20
MISC. HYALOCHAETE CHAET. SPP.		90
CHAETOCEROS GRACILIS	233	10
MISC. COSCINODISCUS SPP.	33	
COSCINODISCUS LINEATUS		10
LAUDERIA BOREALIS		40
MELOSIRA SULCATA	1067	620
NITZSCHIA LONGISSIMA	400	110
SKELETONEMA COSTATUM	367	310
THALASSIONEMA NITZSCHIODES	467	130
MISC. THALASSIOSIRA SPP.	167	60
THALASSIOSIRA AESTIVALIS		80
THALASSIOSIRA PACIFICA	133	60
DINOFLAGELLATES		
MISC. DINOFLAGELLATES	400	
DINOPHYSIS SPP.	333	20
OXYTOXUM SPP.	33	
PROROCENTRUM GRACILE	100	
PROROCENTRUM MICANS	33	
PERIDINIALES	400	20
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	92441	3000

CRUISE SF7605 LAT 48-19 N GMT DATE 08/04/76
STATION 00005 LONG 124-06 W GMT HOUR 2359
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	17	
DIATOMS		
ASTERIONELLA JAPONICA		20
MISC. HYALOCHAETE CHAET. SPP.		180
CHAETOCEROS GRACILIS	33	
COSC. CENTRALIS VAR. PACIFICA	17	
MELOSIRA SULCATA	183	490
NITZSCHIA LONGISSIMA	117	70
THALASSIONEMA NITZSCHIOIDES	333	120
MISC. THALASSIOSIRA SPP.	117	150
THALASSIOSIRA AESTIVALIS	100	20
THALASSIOSIRA NORDENSKIOLDII		10
THALASSIOSIRA PACIFICA		30
MISC. PENNATE DIATOMS		50
DINOFLAGELLATES		
MISC. DINOFLAGELLATES		10
CERATIUM FURCA	17	
DINOPHYSIS SPP.	67	10
PERIDINIUM SPP.	33	
PROROCENTRUM MICANS	33	
PERIDINIALES		10
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	29956	420

CRUISE SF76C5 LAT 48-28 N GMT DATE 08/04/76
STATION 00008 LONG 124-40 W GMT HOUR 1745
ZONE +07

	(OM) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	33	
EBRIA TRIPARTITA	33	
DIATOMS		
ASTERIONELLA JAPONICA		10
BACTERIASTRUM DELICATULUM		10
MISC. HYALOCHAETE CHAET. SPP.		420
CHAETOCEROS GRACILIS	133	40
CHAETOCEROS RADICANS		60
CHAETOCEROS SIMILIS		70
MISC. COSCINODISCUS SPP.		10
EUCAMPIA ZOODIACUS		20
FRAGILARIOPSIS SPP.		50
LEPTOCYLINDRUS DANICUS		10
MELOSIRA SULCATA		170
NITZSCHIA SPP.		120
NITZSCHIA DELICATISSIMA		20
NITZSCHIA LONGISSIMA	500	
SKELETONEMA COSTATUM		430
STEPHANOPYXIS SPP.		10
THALASSIONEMA NITZSCHIODES	633	150
MISC. THALASSIOSIRA SPP.	767	80
THALASSIOSIRA AESTIVALIS		220
THALASSIOSIRA NORDENSKIOLDII		10
THALASSIOSIRA PACIFICA	167	20
MISC. CENTRIC DIATOMS		100
MISC. PENNATE DIATOMS		60
DINOFLAGELLATES		
DINOPHYSIS SPP.	133	
OXYTOXUM SPP.		10
PERIDINIALES	33	20
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	93333	1320

CRUISE SF7606 LAT 48-14 N GMT DATE 09/14/76
STATION 00002 LONG 123-22 W GMT HOUR 2340
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
EBRIA TRIPARTITA		10
DIATOMS		
MISC. HYALOCHAETE CHAET. SPP.	6320	490
CHAETOCEROS DEBILIS	880	
CHAETOCEROS GRACILIS	80	
CHAETOCEROS SIMILIS	120	
MISC. COSCINODISCUS SPP.		10
DITYLUM BRIGHTWELLII		70
EUCAMPIA ZOODIACUS		10
MELOSIRA SULCATA	600	550
NITZSCHIA LONGISSIMA	80	70
RHIZOSOLENIA SPP.	200	
RHIZOSOLENIA STOLTERFOTHII	320	
SKELETONEMA COSTATUM	1200	
THALASSIONEMA NITZSCHIODES	1280	390
MISC. THALASSIOSIRA SPP.	280	120
THALASSIOSIRA AESTIVALIS		30
THALASSIOSIRA DECIPIENS		10
THALASSIOSIRA PACIFICA	160	10
MISC. CENTRIC DIATOMS		10
MISC. PENNATE DIATOMS	320	
DINOFLAGELLATES		
CERATIUM FUSUS	40	
DINOPHYSIS SPP.	40	30
PROROCENTRUM MICANS		20
PERIDINIALES	280	140
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	7240	490

CRUISE SF7606 LAT 48-19 N GMT DATE 09/15/76
STATION 00005 LONG 124-06 W GMT HOUR 2320
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	133	
DIATOMS		
MISC. HYALOCHAETE CHAET. SPP.	600	140
CHAETOCEROS DEBILIS		330
CHAETOCEROS GRACILIS	400	80
COSCINODISCUS EXCENTRICUS		10
COSCINODISCUS RADIATUS		20
DITYLUM BRIGHTWELLII		30
MELOSIRA SULCATA		350
NITZSCHIA SPP.		10
NITZSCHIA LONGISSIMA	200	90
RHIZOSOLENIA SETIGERA		10
RHIZOSOLENIA STOLTERFOTHII	67	
SKELETONEMA COSTATUM		40
THALASSIONEMA NITZSCHIODES	1267	1670
MISC. THALASSIOSIRA SPP.	267	320
THALASSIOSIRA AESTIVALIS		200
THALASSIOSIRA PACIFICA		90
THALASSIOSIRA POLYCHORDA	133	
MISC. PENNATE DIATOMS		20
DINOFLAGELLATES		
DINOPHYSIS SPP.	200	20
PROROCENTRUM GRACILE	400	
PROROCENTRUM MICANS		10
PERIDINIALES	333	20
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	17133	880

CRUISE SF7606 LAT 48-28 N GMT DATE 09/15/76
STATION 00C08 LONG 124-40 W GMT HOUR 1640
ZONE +07

	(0M) CELLS/LITER	(50M) CELLS/LITER
CHRYSOPHYTES		
DICTYOCHA FIBULA	17	
EBRIA TRIPARTITA	83	
DIATOMS		
MISC. HYALOCHAETE CHAET. SPP.	283	
CHAETOCEROS GRACILIS	167	20
MISC. COSCINODISCUS SPP.	17	
COSCINODISCUS EXCENTRICUS		10
COSCINODISCUS RADIATUS	33	10
DITYLUM BRIGHTWELLII		60
MELOSIRA SULCATA		160
NITZSCHIA SPP.		40
NITZSCHIA DELICATISSIMA	67	
NITZSCHIA LONGISSIMA	133	90
THALASSIONEMA NITZSCHIODES	983	810
MISC. THALASSIOSIRA SPP.		60
THALASSIOSIRA AESTIVALIS	50	310
THALASSIOSIRA DECIPIENS		50
THALASSIOSIRA PACIFICA	133	90
THALASSIOSIRA ROTULA		80
MISC. PENNATE DIATOMS		40
DINOFLAGELLATES		
CERATIUM LINEATUM		10
DINOPHYSIS SPP.	50	
PROROCENTRUM GRACILE	17	
PERIDINIALES	150	10
MISCELLANEOUS		
MISC. MICROFLAGELLATE SPP.	15404	210

APPENDIX D

ICHTHYOPLANKTON DISTRIBUTIONS

Distribution of fish eggs and larvae are given in the following tables.

Table D-1. Ichthyoplankton collected with the oblique net during February 1976 (SF7601). Values are average number × $10^3/m^3$ in the upper 50 m.

Ichthyoplankton	Station							
	1	2	3	4	5	6	8	9
Ammodytidae		35						
Ammodytes hexapterus	12				4		4	
Clupea harengus pallasi	4							
Cottidae	16	51	8		15		27	
Cyclopteridae	4	3		6	4			
Gadidae	4			6	12		19	
Gasterosteus aculeatus					4			
Hemilepidotus sp.					4			8
Hexagrammos sp.					15			8
Hexagrammos stelleri								
Isopsetta isolepis							54	
Leptocottus armatus								8
Ophiodon elongatus							4	
Osmeridae	69	71	19	138	77	527	1938	745
Parophrys vetulus		3		3	12		15	
Pholis sp.					23			8
Sebastes sp.	15			3	8		8	8
Stenobrachius leucopsarus							4	
Stichaeidae	15	6		3	8		8	8
Zaniolepis latipinnis	69			10			12	
Fish Eggs		3	12				262	131

Table D-2. Numbers of fish eggs and larvae collected with the pleuston samples during February 1976 (SF7601).

Ichthyoplankton	Station							
	1	2	3	4	5	6	8	9
Ammodytes hexapterus	3	4						
Cottidae		76	1	1				
Cyclopteridae		1						
Gadidae		1			1		1	1
Hemilepidotus sp.				1		2		
Hexagrammos sp.			16	2	35	179		5
Hexagrammos stelleri	23	18						
Ophiodon elongatus	1	8		2		3		
Osmeridae		5					7	13
Parophrys vetulus				1		1		
Stenobrachius leucopsarus							1	
Stichaeidae		20	1					
Zaniolepis latipinnis			1		1			
Fish Eggs		1	2				17	13

Table D-3. Ichthyoplankton collected with the oblique net during April 1976 (SF7602). Values are average number × $10^3/m^3$ in the upper 50 m.

Ichthyoplankton	Station								
	1	2	3	4	5	6	7	8	9
Ammodytes hexapterus	100	738		62					
Bathylagus stilbius									
Clupea harengus							123		
Cottidae	111		337	62					123
Cyclopteridae						123			
Gadidae	177	985	115	123					123
Lepidopsetta bilineata					225		246		738
Osmeridae	100		112	62	225		246		492
Parophrys sp.				123					
Parophrys vetulus		246							
Sebastes spp.	100		225	123		123			
Stichaeidae	122	246	112						
Unidentified fish larvae								369	
Fish Eggs				123					

Table D-4. Numbers of fish eggs and larvae collected with the pleuston sampler during April 1976 (SF7602).

Ichthyoplankton	Station							
	1	2	3	4	5	6	7	8
Ammodytes hexapterus							1	4
Bathymasteridae								2
Hemilepidotus sp.							7	1
Hexagrammidae								2
Hexagrammos sp.	1	6	2	3	3	3	13	4
Lepidopsetta bilineata								3
Ophiodon elongatus							5	
Osmeridae								60
Pleuronectidae						2		
Scorpaenichthys marmoratos							1	
Stichidae							13	9
Unidentified fish larvae					1			
Fish Eggs	9	44	21	12	6	2	1	3

Table D-5. Ichthyoplankton collected with the oblique net during May 1976 (SF7603). Values are average number × $10^3/m^3$ in the upper 50 m.

Ichthyoplankton	Station		
	1	2	3
Artedius sp.	123	137	
Cottidae		137	
Gadidae		137	
Pholidae	123		
Sebastes sp.			112
Fish Eggs			

Table D-6. Numbers of fish eggs and larvae collected with the pleuston sampler during May 1976 (SF7603).

Ichthyoplankton	Station		
	1	2	3
Gadus sp.		3	
Gibbonsia sp.		1	
Platichthys sellatus	1		
Fish Eggs	10	3	10

APPENDIX E

ZOOPLANKTON SPECIES AND MAJOR GROUPS

FOUND DURING SF7601-SF7604

COPEPODA CALANOIDA

Calanidae

Calanus cristatus
C. marshallae
C. pacificus
C. plumchrus
C. tenuicornis

Eucalanidae

Eucalanus bungii bungii

Paracalanidae

Paracalanus n. sp.

Calocalanidae

Calocalanus styliremis

Pseudocalanidae

Clausocalanus lividus
C. parapergens
Ctenocalanus vanus
Microcalanus spp.
Pseudocalanus spp.

Spinocalanidae

Spinocalanus brevicaudatus
S. horridus
S. longicornis

Aetideidae

Aetideus armatus
A. pacificus
Chiridius gracilis
Euchirella pulchra
Gaetanus simplex
Gaidius columbiae
G. variabilis
Pseudochirella polyspina

Euchaetidae

Euchaeta elongata

Scolecithricidae

Amallothrix inornata
Racovitzanus antarcticus
Scaphocalanus brevicornis
Scolecithricella minor

Temoridae

Eurytemora americana

Metridiidae

Metridia curticauda
M. Lucens
M. okhotensis
Pleuromamma quadrungulata

Centropagidae

Centropages abdominalis

Candaciidae

Candacia columbiae

Pontellidae

Epilabidocera longipedata

Acartiidae

Acartia clausii
A. danae
A. longiremis

Tortanidae

Tortanus discaudatus

COPEPODA CYCLOPOIDA

Oithonidae

Oithona similis
O. spinirostris

Oncaeidae

Oncaea borealis
O. conifera
O. prolata
O. sp.

Corycaeidae

Corycaeus anglicus

COPEPODA HARPACTICOIDA

Aegisthidae

Aegisthus mucronatus

Ectinosomidae

Microsetella rosea

CHAETOGNATHA

Sagitta elegans
S. lyra

POLYCHAETA

MEDUSAE

Campanulariidae

Phialidium gregarium

SIPHONOPHORA

CTENOPHORA

GASTROPODA

CEPHALOPODA

CLADOCERA

Polyphemidae

Evadne nordmanni
Podon leuckarti

OSTRACODA

Halocypridae

Conchoecia alata minor

ISOPODA

AMPHIPODA

Calliopiidae

Calliopius laeviusculus

Lysianassidae

Cyphocaris challengeri

Hyperiidae

Hyperoche medusarum
Parathemisto pacifica

Phrosinidae

Primno macropa

MYSIDACEA

CUMACEA

Diastylidae

Diastylopsis dawsoni

EUPHAUSIACEA

Euphausiidae

Euphausia pacifica
Thysanoessa longipes
T. spinifera

DECAPODA

Pasiphaeidae

Pasiphaea pacifica

CHORDATA - Urochordata

Fritillariidae

Fritillaria sp.

Oikopleuridae

Oikopleura dioica